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Securities Processing: The Effects of a T+3 System on Security Prices

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To the Graduate Council:

I am submitting herewith a dissertation written by Victoria Lynn Messman entitled "Securities Processing: The Effects of a T+3 System on Security Prices." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Business Administration.

Ramon P. DeGennaro, Major Professor

We have read this dissertation and recommend its acceptance:

Phillip R. Daves, Larry Fauver, Mohammed Mohsin

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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A Dissertation Presented for
the Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Victoria Lynn Messman
May 2011

Dedication

This dissertation is dedicated to my loving family, especially my husband, Jamie, and my parents, Merry and Steve. Thank you for your unyielding support, encouragement, and patience.

Acknowledgments

I wish to thank Dr. Ramon P. DeGennaro, who served as the chairman of my dissertation committee, for his time, patience, ideas, helpful comments, and overall contribution to my dissertation. I would also like to thank the other members of my committee for their time and contributions: Phillip R. Daves, Larry Fauver, and Mohammed Mohsin. Thank you to the University of Tennessee Finance Department for support during my graduate studies and to all the participants in the brown bag seminars for helpful comments and suggestions. All errors and omissions are my own.

Abstract

This study investigates the settlement period, including payment delays and failed deliveries that occur during the processing of U.S. equity transactions, and its effects on observed stock prices. Payment and delivery occur three to six calendar days after the trade date in the standard three business day settlement cycle, referred to as T+3.

First, the buyer benefits from a payment delay, during which time he can earn interest on the cash needed to settle the trade. Since the seller has no analogous opportunity, I anticipated that the cost of the payment delay would be reflected in equity prices at a rate equivalent to the risk-free rate over the settlement period in ordinary circumstances and at a higher rate during financial market crises if sellers believe they may not be paid on time. Using CRSP daily market index returns from 1995 through 2009, I measured the cost of this delay to be approximately three to five times the risk-free rate, proxied by the effective Fed funds rate. These results suggest that buyers are forced to compensate sellers at rates greater than I expected during normal conditions.

Second, the risk of failed delivery may also affect security prices if market participants expect that sellers will not deliver securities on time. A failed delivery effectively becomes a forward transaction. I predicted that buyers compensate sellers at the risk-free rate over the extended settlement period. This compensation would be in addition to the normal payment delay and directly related to the probability of failed delivery; thus, I added SEC Regulation SHO daily failed deliveries data, available from 2004 through 2009, to the model with payment delays. By constructing a proxy for the change in probability of failure from aggregated fails and market volume, I found that buyers compensate sellers over the lengthened settlement period due to failed deliveries at a rate of approximately 11 basis points daily for an increase in the likelihood of failure of one percentage point.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

ACT	Automated Confirmation Transaction (NASDAQ comparison system)
BD	Broker-Dealer
CCA	Clearing Cash Adjustment
CCP	Central Counterparty
CNS	Continuous Net Settlement
CRSP	The Center for Research in Security Prices
DOT	Designated Order Turnaround (NYSE comparison system)
DTC	The Depository Trust Company
DTCC	The Depository Trust & Clearing Corporation
DVP	Delivery Versus Payment
FTD	Fail to Deliver or Failure to Deliver
GARCH	Generalized Autoregressive Conditional Heteroscedasticity
NASD	National Association of Securities Dealers
NASDAQ	National Association of Securities Dealers Automated Quotation system
NSCC	National Securities Clearing Corporation
NSS	Naked Short Sale or Naked Short Selling
NYSE	New York Stock Exchange
SBP	Stock Borrow Program
SEC	Securities and Exchange Commission
SIA	Securities Industry Association
SIPC	Securities Investor Protection Corporation

I. Introduction

This study investigates payment delays and failed deliveries in the processing of U.S. equity transactions.[1] In the current institutional framework, when two parties enter into a trade today, called day T, the transaction settles in three business days, on T+3, under normal circumstances. Cash and securities change hands at settlement. Due to intervening weekends and holidays, the T+3 system results in settlement occurring three to six calendar days after the trade. The consequent payment delay benefits the buyer because he can earn interest on the cash needed to settle the trade over the settlement period, while the seller has no equivalent opportunity. The risk of failed delivery may also affect security prices if market participants expect that sellers will not deliver securities on time. In this study, I investigate whether observed stock prices reflect the settlement period.

When a buyer and seller enter into an agreement to trade cash for equity securities, both are exposed to counterparty risk. The seller is subject to the buyer's credit risk, or the risk that the buyer may not have the money to pay him on the settlement date. The buyer is exposed to the risk of the seller's failure to deliver, meaning that the seller may not deliver the securities on the settlement date. Counterparty risk can be very high if trades are bilateral agreements, but the contemporary security processing system described herein gives traders seemingly safer options. Since 1973, the move away from the physical transfer of paper stock certificates toward a central depository coupled with electronic transfer of ownership should have alleviated the risk associated with failure to deliver. Since 1976, a central processing organization has evolved. It has improved the settlement process for financial market participants by guaranteeing settlement of all trades, by assuming counterparty risk, and by requiring trading parties to deposit collateral for settlement. This advancement should have lessened risks associated with both buyer's credit and failure to deliver. Since 1995, the modern security processing system has been characterized by settlement under the shortened T+3 system. Overall, after-trade processing of equity transactions appears safer and faster than ever before. Therefore, I analyze the question: Is the system safer?

To answer this question, I consider prior evidence, particularly a study by DeGennaro (1990), who examines the effect of payment delays on stock prices during a time period when different institutional details dictated the processing of equity trades. The study uses data from 1970 to 1982, when the settlement cycle was longer due to both a T+5 cycle and an additional business day for check clearing, resulting in payment delays of up to 12 calendar days. Modeling stock returns as a function of payment delays, he finds that buyers compensate sellers for the payment delay at the risk-free rate, which he proxies with the Fed funds rate, over the entire sample. However, in one subperiod (1970-1972), he finds that the premium was over four times the risk-free rate. He suggests that this may be the result of the government's attempt to control wages and

[1] This study deals only with common stock unless otherwise stated.

prices, or it could be due to the wrong interest rate proxy. Then again, sellers may be demanding this premium because of potential processing errors that are costly to fix and that delay payment by more than six business days. In addition, his study explores whether payment delays explain the day of the week effect, but when the payment delay is controlled for, the effect still exists.

By comparison, I use data from the T+3 settlement regime in this study. During this time, cash is available to the seller without delay for check clearing on the settlement day. First, I identify and measure the compensation for the three business day payment delay, which is a by-product of the processing system that takes place for every normal equity transaction. A knowledgeable seller realizes that the buyer gets to use his money for three business days after the trade, knows what this delay is worth, and builds a premium into prices to compensate himself. Competition forces the buyer to pay this premium. If the seller only demands compensation for the time value of money, then his return over the settlement period may be at the risk-free rate. Or, he may require a risk premium. For example, in the 2008 financial crisis, when financial institutions were closed or sold over the weekend, sellers may have built a greater rate of compensation than the risk-free rate into the price of equity securities. This risk premium may indicate investors' lack of confidence in their probability of getting paid on time if a firm disappears or is inundated with transactions. In general, it may indicate investors' lack of confidence in financial markets or financial institutions.

I attempt to confirm that equity prices reflect compensation to sellers for payment delays, as expected by theory and prior research. Moreover, I am interested in whether that compensation is at the risk-free rate of return. I expect to find the settlement period return is equal to the risk-free rate for the following reasons. First, the payment delay is standard across all trades and reflects that security prices may be considered forward prices rather than spot prices since the transaction is actually settled three business days after the trade date. Second, the payment delay was found to be compensated at the risk-free rate in prior work [DeGennaro (1990)] under a presumably more risky institutional framework. If the processing system has become less risky, then it seems that the compensation for payment delays should not reflect a risk premium.

I also incorporate data on delivery failures. After a trade is executed, sellers may fail to deliver securities on time. As opposed to payment delays, which are a certain consequence of the processing system, failures are a complication that may occur during the settlement cycle. A failed delivery effectively becomes a forward transaction, regardless of whether the transaction involves broker-dealers (BDs) or institutions. Therefore, I predict that, in general, buyers compensate sellers at the risk-free rate over the extended settlement period.

However, the expected effect on buyers varies depending on the circumstances and on the type of buyer. Normally, individual investors are unaffected; they pay their BDs on the original settlement date, and they accrue all the benefits of ownership regardless of when their BDs take delivery of the securities. In abnormal circumstances, around periods of great uncertainty or financial crises for instance, individual investors may assess fails with more scrutiny and build a discount into prices. These buyers may refuse to compensate sellers since they do not benefit from a forward contract. In fact, they may require a lower price to acquire some of the benefit that their BD extracts from failed deliveries. This outcome may signal a lack of confidence in a clearing firm or member to fulfill its obligation to deliver securities, not just on time, but perhaps, at any time in the future.

Buyers' BDs may benefit from failed deliveries because they receive a forward transaction; additionally, they receive cash from their clients on the original settlement date. Similarly, institutional investors may benefit from an extension of the payment delay since they, too, do not pay for securities until delivery. However, buyers' BDs and institutions may lose out on the opportunity to lend a stock on special with a high specialness spread if the seller fails to deliver it.

In sum, I investigate the following questions in this study. How important is the settlement delay on security prices? Do failures to deliver have an economically significant impact on prices? Do equity prices reflect that failures to deliver benefit the buyer or the seller? Has market structure stability been enhanced due to a safer processing system as a result of the central processing organization?

In the next section, an overview of securities transactions processing is provided. The third section describes short selling, failures to deliver, and Regulation SHO. Section IV develops the model, and section V discusses the data. The sixth section reports empirical results and discusses their implications. Section VII concludes, and section VIII suggests areas for future research.

II. Overview of Securities Transactions Processing

When a buyer and seller enter into a sales agreement to exchange equity securities for cash, they make a trade. Weiss (2006) discusses the period of time that follows in *After the Trade is Made*, focusing on the clearing, delivery, and settlement procedures. Clearing refers to all of the processes that occur after a trade is made except for the final settlement process. Settlement is the last step and entails payment and delivery. On the date of the trade, called T, the buyer and seller agree to a price for the trade, but settlement actually occurs several days later. Currently, it takes three business days to process equity transactions, and the length of the settlement cycle is commonly referred to as T+3. Settlement cycles vary for different types of securities at present as shown in Table 1. In the commercial paper market, transactions settle on the trade date, or T. Futures, options, and U.S. Treasury securities settle on T+1, and currency transactions settle on T+2. Besides equities, corporate and municipal bonds also settle on T+3, or three business days after the trade date.

Length of the Equities Settlement Cycle

Equities settled on a T+4 time frame prior to February 1968. Around that time, trading volume was heavier than the processing channels could accommodate, forcing the New York Stock Exchange (NYSE) to close periodically from 1967 through 1970. Starting in August of 1967, intense back office workloads required early closure for a couple of weeks. This was repeated for a substantial portion of the first quarter of 1968. A major contributor to this problem was the physical transfer of stock certificates, which took too much time and was a drag on the efficiency of the financial system. Consequently, to keep up with the paperwork, the time to process the sale or purchase of equity securities was lengthened.

Table 1. Present length of settlement cycle for various securities.

Settlement Cycle	Type of Security
T	bank certificates of deposit (CDs) commercial paper
T+1	futures options U.S. Treasury securities
T+2	currency or foreign exchange
T+3	corporate and municipal bonds equities

On February 9, 1968, the processing time frame was extended by one business day to T+5 in response to this financial market paperwork crisis. Even after the settlement timeframe was extended, backlogs of paperwork compelled the market to close all day on Wednesdays during the second half of 1968. While the market reverted to a five day week at the beginning of 1969, it did not return to full trading hours until May 1970.

The paperwork crisis highlighted how after-trade processes needed to be streamlined. A more modern approach would require clearing and settlement to be centralized and automated. Physical stock certificates needed to be immobilized and kept in a central location. Rather than delivering paper certificates, changes in ownership could simply be recorded by a depository. As one solution to the NYSE paperwork crisis of the 1960s, the Depository Trust Company (DTC) was created in 1973 as a central repository where paper certificates could be kept in one location and transfer of ownership could be enacted by record changes in a centralized database. The process to transfer ownership is referred to as book entry. DTC eliminated the need to physically transfer paper stock certificates, which alleviated the paperwork crisis. The National Security Clearing Corporation (NSCC) followed in 1976 to fulfill the need for a central processing organization. As discussed in detail in the section below describing the Depository Trust and Clearing Corporation (DTCC), NSCC manages back office settlement matters, including tracking information, comparing trade details, netting trades intrafirm,[2] acting as central counterparty to both sides of a trade, and filling receives with delivers during settlement.

Weiss (2006) discusses how financial leaders from around the world gathered in the mid-1980s to devise a list of process improvements, known as the G30 recommendations, that would help financial markets deal with increased transaction volume due to market growth and globalization. It called for netting trades on the street side[3] of the trade as well as rolling unsettled trades – either fails to receive or fails to deliver – forward to the next day's settlement. Although the increase to T+5 was necessary to accommodate the back office bottleneck, a longer settlement timeframe increases risk. Therefore, additional recommendations included shortening the settlement cycle to T+3 on corporate securities and settlement in same-day funds, which are available immediately upon receipt.

By the mid-1990s, these improvements had been made. Processing had been automated and streamlined. Few people were holding actual stock certificates. In fact, most physical stock certificates had been replaced entirely by book entries in the computer database at the DTC. Paperless securities are said to be dematerialized,

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[2] Netting, which is described in detail below, minimizes the number of receives and delivers between broker-dealer firms by pairing off transactions within each firm first.

[3] The street side of the trade involves the processing portion of the trade that is carried out between the two opposing broker-dealers – one on the buy side and one on the sell side – involved in the trade. This is in contrast to the client or customer side of the trade, which involves the parts of the trade that are carried out between the broker-dealer and his client.

which is the next logical step beyond immobilizing the stock certificate. The system for processing equity transactions transitioned from T+5 to the current T+3 system on June 7, 1995.

In 2000, some members of the financial industry, including the DTCC, the Securities Industry Association (SIA), and the Securities and Exchange Commission (SEC), discussed shortening the settlement cycle for U.S. equities and corporate bonds from T+3 to T+1 by 2004. Shorter settlement cycles have several benefits. SIA anticipated that settlement exposure would decline dramatically, by 67% or $250 billion, in the move from T+3 to T+1. Collateral put up by members of clearing corporations would also drop by 67% since members would have fewer open positions at any time. Also, fewer pending settlements would decrease risk. While SIA estimated the costs for the industry at about $8 billion with an annual savings of $2.7 billion per year after the transition, critics posited that the initial cost would be much higher. In 2001, the target date for the transition was extended to 2005. Priorities shifted after 9/11, and the costs to convert to a shorter time frame appeared to outweigh the benefits. In 2002, the plan to shorten the settlement cycle was abandoned altogether. However, European markets have recently revived the discussion, proposing to move from T+3 to T+2 and to join the German market that already settles on T+2.[4] In turn, DTCC's CEO has publicized the need for discussion on shortening the settlement cycle in the U.S. equity market to alleviate systemic risk in the aftermath of the 2008 financial crisis.[5]

Types of Trades

There are different types of investors. The two main categories are individual investors and institutional investors. While there are many more individual investors in the market, institutional investors manage portfolios that are enormously larger than those of individual investors. Over the past decade, U.S. investments in equities are characterized by individuals holding an average of just under 40% of the outstanding market value and institutions holding the remaining 60% or so.[6] The type of investor affects how trades are processed. There is an important distinction between the two main types of trades: trades between two BDs and institutional trades.

Individuals must trade through retail channels and use the services of a broker or a dealer to accomplish their buying and selling. Thus, individual investors' trades are always conducted with the aid of a BD, and all trades for individual investors that are

[4] If you simultaneously buy equities in Germany, which will settle on T+2, and sell equities in another market that operates on T+3, you will experience a one business day shortfall in funds.
[5] Source: Donald F. Donahue, CEO and Chairman of DTCC in his June 2, 2010 speech entitled "Setting the Frame: Risk, Technology and Cooperation" in Wolfsberg, Switzerland.
[6] Data used to calculate this estimate were obtained from the Federal Reserve Flow of Funds Accounts, Release Z.1 Table L.213 Corporate Equities available at www.federalreserve.gov.

reported to a clearing agency are known as trades between two BDs, or broker-to-broker trades.[7]

An institutional trade, on the other hand, is generally more complex than retail trades between two BDs. This is because they involve larger amounts of money and large blocks of securities, more parties to the transaction, and more steps between the initial entry of the order and the final settlement.[8] In fact, the trade may take place entirely with another institution or it may be broken into smaller pieces to prevent greatly impacting prices. Moreover, institutional trades may take place over multiple days. Similar to individual trades, institutional trades are still completed with the help of BDs. The specific details of settlement cycles for both types of trades are discussed below.

BDs maintain positions in securities both for themselves or their firm and for their clients. Clients' securities are often held in street name, meaning the BD holds the securities for these clients. The BD is not the beneficial owner[9] of the security; the client is. BDs also trade for their own accounts. However, these positions must be segregated from client positions. In other words, BDs may not combine securities belonging to their clients with their own trading accounts or securities positions.

Weiss (2006) further distinguishes the types of trades that BDs engage in with their clients, whether they are individuals or institutions. These types of trades are summarized in Table 2. In ordinary principal transactions, the BD fulfills a customer's order by buying or selling securities in the firm's trading account. Since this is an internal transaction, the order is not processed by a clearing corporation.

The remaining types of transactions are reported to and processed by a clearing corporation. In market-maker transactions, the BD acts as a dealer in a security and buys or sells from his inventory to complete the customer order. In an agency transaction, the BD takes on the role of an agent for the client and charges a commission on the purchase or sale of a security. Finally, a modified principal transaction occurs when a customer's order is executed after the firm buys securities from a market-maker for the firm's internal trading account, charges a mark-up, and trades with the client as an ordinary principal. Although this happens mostly for debt, it

[7] An individual investor may also trade directly with his BD only in an ordinary principal transaction, as described below. However, this would not be reported to the clearing agency.
[8] Block trades, often used by institutional investors, involve selling 10,000 shares or more of a stock in one transaction.
[9] Under the Securities Exchange Act of 1934, a beneficial owner of a security is a person with voting power ("the power to vote or direct the voting" of the security) and investment power ("the power to dispose or direct the disposition" of the security). A national securities exchange member is not the beneficial owner if it holds securities on behalf of another person (directly or indirectly) and, as the record holder, is allowed to vote without instruction on matters that do not substantially alter the rights or privileges of the security holder.

Table 2. Types of trades.

Transaction	Description	Information Sent to Clearing Corporation[10]
Ordinary Principal	Customer's order is executed against the trading account of the firm internally.	Nothing.
Market-Maker	Dealer trades with customers or other non-dealer firms and profits from the bid-ask spread.	Details of the trade.
Agency	BD acts as an agent for the client and charges a commission.	Details of the trade.
Modified Principal	Firm buys securities from a dealer, passes them through internal trading account, charges a mark-up, and proceeds as in an ordinary principal transaction.	Details of the trade for firm's transaction with a dealer; nothing for ordinary principal transaction.

is occasionally used for equity transactions. For instance, if the BD was a market-maker when the client originally bought the security, then the client paid no commission fee. If the BD no longer makes a market in the security when the client wants to sell at a later date, he may charge a mark-up rather than a commission to avoid upsetting the client with a new, and observable, fee.

Payment Trends

Securities were often purchased with checks in the past, forcing the seller to wait an additional business day for the check to clear before using the money. The seller received "clearinghouse funds" on the settlement day; these funds earned no interest and were unavailable for use until the next business day when the money became Federal funds. Thus, early studies that explored payment delays to equity traders included an additional day to account for check clearing [e.g., see Lakonishok and Levi (1982) and DeGennaro (1990)].

Presently, the money part of nearly all transactions between BDs is settled over Fedwire. The Fedwire Funds Service is provided by the twelve Federal Reserve Banks as a communication network for real-time gross settlement. Participating financial institutions with an account at a Federal Reserve Bank may initiate funds transfers online or by phone; money transferred is available to the recipient immediately.

[10] All trades reported to the clearing corporation are also reported to the market and thus available in the data source for the study.

Members commonly use the service for payments that are high in value and time sensitive. Fedwire is open Monday through Friday on non-holidays. For a payment on any of these days of the week, transfers may be initiated anytime between 9:00 p.m. Eastern time on the calendar day preceding the payment day and 6:30 p.m. Eastern time on the payment day.

According to Weiss (2006), prior to 1995, trades were settled with next-day funds, meaning the recipient could not use them until the next day. However, in 1995, trades started settling with same-day funds, almost all of which were sent over Fedwire. Note that both the BD and his client receive same-day funds on the settlement date. In other words, there is no additional payment delay, beyond three business days, in this regime for the individual investor.

According to the 2007 Check Sample Study, less than 20% of checks in 2006 were written for transactions over $500.[11] These results are based on a sample of many large commercial banks that processed about 40% of all checks in the U.S. that year. Since most checks are written for values of $500 or less, this provides additional evidence that few trades are settled by check on either the street or client side.

Even if clients use checks, they are subject to shorter payment processing times. Effective October 28, 2004, “Check 21” decreased the float time for personal checking by shortening the time for a check to clear. Now, if an individual writes a check today, the Federal Reserve recommends that he have money in his account to cover that expense today. The check clearing process has become much more efficient over time since banks can now transfer an image of a check electronically as opposed to physically delivering paper checks for payment. Moreover, it is possible for a check to clear the same day as it is written; for example, if the payee presents the check at a branch of the bank from which the check is written, the payer’s account may be debited that same day.

However, check processing should not affect security prices. While checks may be used by some clients of BDs, funds must be available in the account by the settlement date. The buyer can continue to use his cash during the time from trade to settlement, but he must have assets in his account equal to the purchase value. If the funds are not available by the settlement date, BDs have the authority to liquidate other assets to meet settlement obligations.[12] Furthermore, clients receive same-day funds from BDs.

[11] This survey is available at http://www.frbservices.org/files/communications/pdf/research/2007_check_sample_study.pdf.
[12] A Vanguard Brokerage Services customer service broker provided this information in the fall of 2009.

The Depository Trust and Clearing Corporation

Billions of shares of securities are traded on a daily basis in the U.S. As the largest organization in the world that provides post-trade infrastructure to financial markets, the DTCC processes most of these trades. The DTCC and its subsidiaries provide clearing, settlement, and information services. Securities settled through DTCC in 2008 were valued at $1.88 quadrillion.[13] Of its seven subsidiaries, the divisions that clear and settle equity transactions include the NSCC and the DTC. NSCC exists to speed up settlement of equity and corporate and municipal debt transactions for securities listed on the NYSE, American Stock Exchange (Amex)[14], and NASDAQ. DTC tracks changes in ownership and allows for immobilization of physical stock certificates and book-entry.

In 2008, the NSCC processed over $315 trillion in equity and bond transactions. This consisted of nearly 22 billion transactions, or an average of about 88 million transactions per day. Table 3 shows the growth in annual transaction statistics from DTCC, NSCC, and the SEC. DTCC data includes settlement of securities for all of its subsidiaries. NSCC data includes both the dollar value and the volume of equity and corporate and municipal bond transactions processed by NSCC. SEC data shows the dollar value of all equity transactions in the market. Figure 1 show the growth in equity transactions reported by the SEC in dollars.

Some considerations regarding the NSCC and SEC statistics are necessary. Characteristics of the data make comparisons difficult. NSCC figures count the buy side and sell side separately; in other words, NSCC double counts.[15] The SEC reports the market value of all sales of equities, so the SEC data should be compared to half the NSCC data. After adjusting, the SEC values are much lower. In fact, the halved NSCC values exceed the reported SEC values by the following: 2.00 times[16] in 2008, 2.24 times in 2007, 2.09 times in 2006, 1.97 times in 2005, and 1.85 times in 2004.

NSCC reports statistics for corporate and municipal bonds as well as equities while the SEC reports the value for equities only, suggesting that NSCC values should be higher due to the inclusion of bonds. The NSCC does not report statistics for equities alone. Conversely, the SEC equity values include institutional trades whereas the NSCC only reports trades between two BDs. The SEC does not report statistics for trades between

[13] All statistics in this section are from the DTCC website at www.dtcc.com/about/business/statistics.php.
[14] According to http://www.nyse.com/about/history/timeline_chronology_index.html, NYSE and Archipelago Holdings, Inc. merged March 7, 2006 to form the NYSE Group, Inc. On April 4, 2007, NYSE Group, Inc. and Euronext N.V. merge to form NYSE Euronext. NYSE Euronext acquired Amex on October 1, 2008.
[15] Source: DTCC Media Statement from June 28, 2006 "DTCC Clarification on Fails to Deliver."
[16] Calculated as ($315.1 trillion ÷ 2) ÷ $78.7 trillion.

Table 3. Transaction statistics from DTCC,[17] NSCC,[18] and the SEC.[19]

Year	2004	2005	2006	2007	2008	2009
DTCC Transactions						
Total Value ($)	1.1 Q	1.4 Q	1.53 Q	1.86 Q	1.88 Q	1.48 Q
NSCC Equity and Bond Transactions						
Value ($)						
Total	100.4 T	130.7 T	174.9 T	283.2 T	315.1 T	209.7 T
Daily Average	402 B	523 B	700 B	1,137 B	1,255 B	835 B
Peak Day	494 B	765 B	1,020 B	2,230 B	3,273 B	n/a
Volume (# of Transactions)						
Total	5.8 B[a]	6.6 B	8.5 B	13.5 B	21.9 B	23.2 B
Daily Average	23 M	26 M	34 M	54 M	87 M	92 M
Peak Day	30 M	37 M	50 M	99 M	209 M[b]	n/a
Date of Peak	May 10	Oct 6	June 8	Aug 16	Oct 10	n/a[c]
SEC Equity Transactions						
Value ($)						
Total	27.2 T	33.2 T	41.8 T	63.1 T	78.7 T	n/a
NYSE	11.7 T	14.4 T	16.3 T	17.3 T	12.8 T	n/a
NASDAQ	8.0 T	10.4 T	17.8 T[d]	17.1 T	25.0 T	n/a
Daily Average	109 B	133 B	167 B	252 B	315 B	n/a

Q = quadrillion (10^{15}); T = trillion (10^{12}); B = billion (10^{9}); M = million (10^{6})
Daily average statistics assume 250 trading days per year.

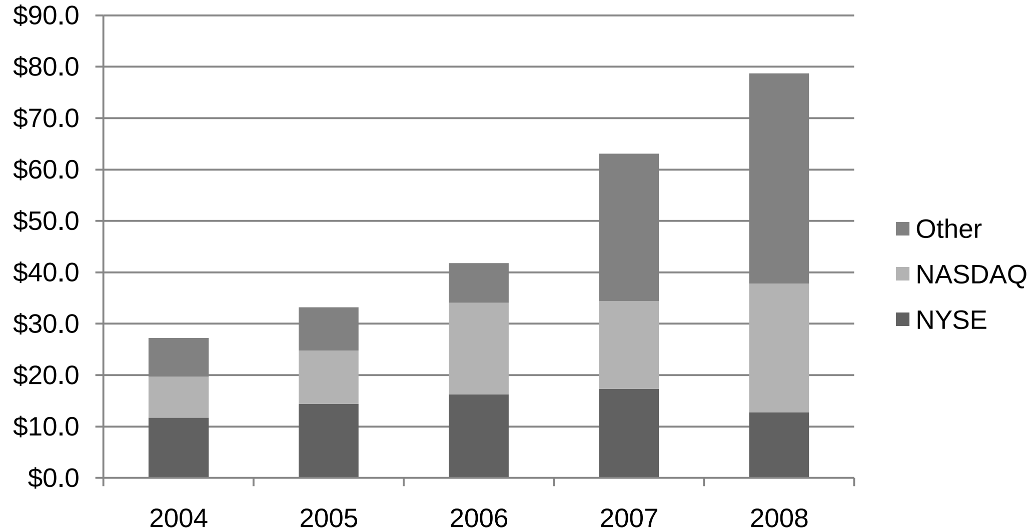
[a] Average of 1,247 shares per transaction.[20]

[b] The 2008 DTCC Annual Report states 19.3 billion shares were processed (averaging 92 shares/transaction). In opposition, the 2009 DTCC Annual Report states 85.7 billion shares were processed on October 10, 2008 (averaging 409 shares/transaction).

[c] DTCC reports no new peak day in 2009 for NSCC transactions, but it does report a peak day for number of shares processed. On August 24, 2009, 96.7 billion shares were processed.

[d] Includes $2.4T from NASDAQ and $15.4T from NASD, reported separately in this year only.

[17] Data obtained from DTCC annual reports.
[18] Data obtained from DTCC annual reports. The values reported are prior to netting. For example, NSCC processed $315.1 trillion in transactions in 2008 prior to netting. Netting reduced trade obligations by over 99% to $2.9 trillion. In addition, the DTCC value and volume measures double count all trades to include both the buy side and sell side.
[19] Data obtained from Select SEC and Market Data 2004-2009 available on www.sec.gov/about.shtml.
[20] The size of the average equity trade was 836 shares in 2003, 780 shares in 2001, and 758 shares in 2000 according to the 2004 and 2001 DTCC Annual Reports.



The market value of equity sales is reported. 'Other' includes trades reported by some combination of exchanges, regulatory agencies, and electronic marketplaces, such as the American Stock Exchange (Amex), Archipelago Exchange, BATS Exchange, Inc., Chicago Stock Exchange, Financial Industry Regulatory Authority (FINRA)[21], International Securities Exchange, National Stock Exchange, Pacific Exchange, and Philadelphia Stock Exchange.

Figure 1. SEC-reported value of equity transactions in trillions of dollars.

two BDs alone. From 2004 to 2009, institutional block trades accounted for around 16% of the dollar volume of all trades on average.[22] In 2008, the $79 trillion reported by the SEC is made up of 10% average dollar volume of institutional trades in that year, or about $8 trillion. The remaining $71 trillion in trades may have been reported to NSCC as trades between two BDs. This suggests that NSCC reports 220% ($158T / $71T), rather than 200% as calculated earlier, of the value reported by the SEC when institutional trades are excluded from the SEC data.

Members of DTCC paid fees for equity clearing that amounted to about a third of a cent for each transaction in 2008, or under seven hundredths of a penny for each 100 shares

[21] According to http://www.nyse.com/about/history/timeline_chronology_index.html, NASD and NYSE Regulation combined to form FINRA in July 2007.

[22] This calculation is based on the percentage obtained when NYSE Group block volume in NYSE listed securities is divided by all NYSE group volume in NYSE listed securities on a monthly basis from January 2004 to December 2009. The average was 20% for share volume, 0% for number of trades, and 16% for dollar volume. Average share volume declined over time from 27% (2004-06 data) to 14% (2007-09 data). Prior to this sample, Francis and Ibbotson (2002), report that block trades accounted for over 50% of NYSE share volume in 1997. The SIA reports that in 2001 the average daily number of institutional trades executed was 656,888, an 11.5% increase from 2000. (Source: SIA 2002 Factbook.)

on average.[23] From 2006-2008, the number of U.S. equities transactions processed by NSCC doubled, yet annual expenses were constant at $100 million per year. Members pay fees to reimburse DTCC for its services. Based on their usage, costs are split proportionally between members. The DTCC attempts to price its services to cover its costs and returns excess revenues to members in the form of discounts and other refunds. Profits are also distributed to members, who are obligatory preferred shareholders, in the form of dividends.

The DTC had nearly $28 trillion worth of securities on deposit in 2008. When securities are not in the depository, they may be in BD vaults, custodial banks, in transfer, or out on stock or bank loan. Also, investors today can still hold securities in the form of physical certificates. If they do so, the security is registered with the issuing firm in the investor's name. As proof of ownership, the investor receives a tangible security certificate. In 2000, the SIA reported its survey of individual investors who had requested securities in certificate form in the recent past. These individuals had the following characteristics. Most were over the age of 55, had at least ten years of investing experience, and traded infrequently on a monthly basis. Around half owned a computer and used the Internet; a similar proportion said they would still invest without certificates. The SIA concluded that some investors still covet the physical security certificate. However, this group includes few investors under 55, suggesting that most investors are likely to accept dematerialization over time.

If no physical certificate is issued, ownership is documented by book-entry, either by street name registration through a BD or by direct registration through the issuing firm or its transfer agent. Street name registration means that the issuing firm records the investor's BD firm as the owner, and the BD records that the investor is the beneficial owner. Direct registration means that the issuing firm records the investor as the owner.

Most investors are willing to hold dematerialized securities in street name with their BD. Similarly, most clients' security positions are maintained by their BDs at DTC. BDs often keep all of their equities, corporate and municipal debt, and money market securities at DTC. The client is the beneficial owner of the security, but the securities are registered in street name. Equities held in street name are referred to as fungible and can be substituted. This means that if a particular share of stock is lent out, it must be replaced with another equivalent share of stock of the same issuing company; it does not have to be replaced with the exact same share. DTC carries securities in its street name, CEDE, which stands for Central Depository.

[23] The cost to clear a trade has fallen substantially. Historically, the cost per side has been: 82 cents in 1977, 35 cents in 1983, 7 cents in 2001, 4.7 cents in 2002, 4.3 cents in 2004. Source for statistics for 1977 and 2004: Jill M. Considine, CEO and Chairman of DTCC in November 1, 2004 speech at the 8th Asia-Pacific CSD Group annual meeting, "Building a Flexible Model for the Future; Making Organizations Responsive." Source for statistics for 1983, 2002, and 2008: 2008 DTCC Annual Report. Source for the 2001 statistic: 2001 DTCC Annual Report.

When a client wants his securities registered in his own name rather than in street name, the securities held in the beneficial owner's name must be paid for in full. The client can either take possession of the shares himself or ask the BD to hold the securities. When the BD keeps the shares registered in his client's name, this is a service referred to as safekeeping and carries a fee. Since these shares cannot be purchased on margin, they are not available for lending to short sellers. In fact, the BD may not use them for any purpose. Therefore, the safekeeping fee compensates the BD for carrying, storage, and records associated with keeping the shares in a separate account. If the client takes possession of the shares registered in his name rather than safekeeping, then he does not incur the fee. However, selling the shares may take more time since the client will have to deliver them to his BD.

When stock is registered in street name, it can be maintained electronically, accepted as a good delivery at any BD or bank, and used by the BD to conduct daily business. Moreover, a client will receive the proceeds of a sale faster for a stock registered in street name than for a stock held in the client's own name since he does not have to wait until the stock clears transfer. For a stock registered in street name, the client will receive the proceeds of the sale on the settlement date, or T+3. For a stock registered in the client's name, the client may not receive the proceeds of the sale on T+3; he may have to wait longer because he must present a power of attorney document that transfers ownership from himself to the BD in street name. Once ownership is transferred, the client will receive the proceeds of the sale.

Settlement Cycle for Trades between Two Broker-Dealers

Trade Comparison

The initial step in the settlement cycle is the comparison of trade details between the opposing parties to the trade. Within seconds after the trade is executed, the details must be submitted and compared. The reporting party is generally the sell side. However, if the sell side is a broker and the buy side is a dealer, then the dealer reports. The non-reporting party must accept the terms of the trade in order for it to be processed and for details to be forwarded on to a clearing corporation, like NSCC. On the NYSE, BDs use the Designated Order Turnaround (DOT) system. For NASDAQ, BDs use the Automated Confirmation Transaction (ACT) system.

Nearly every trade that is submitted to NSCC these days has been compared by the two BDs involved in the trade. This makes it easy for the clearing corporation to produce a contract sheet as an electronic record. If the BDs are both participants at NSCC, known as clearing firms, then they receive this computer-generated report, which highlights all of their compared trades (both sides match), uncompared trades (the BD's submission does not match the other side), and advisory trades (the BD does not know about the other side's submission.) BDs investigate and clean up uncompared and advisory trades as quickly as possible.

The evolution of the comparison process helped make clearing more efficient. In the past, comparison of trade details was cumbersome and full of errors. Both BDs were required to present all of the details of their trades to the clearing corporation, including trade date, quantity, security, price, first money (quantity times price), and the name of the other broker. The details were initially recorded on an exchange floor report or in the trader's handwritten notes. Another individual in a different department of the BD firm who had no involvement in the trade would transcribe this report or the notes to prepare a comparison form. Then, the clearing corporation would match the data, compare it, and send a contract sheet report back to both BDs who would verify the details. This was inefficient and too time consuming for a T+3 settlement cycle.

As technology improved, the BDs could electronically submit their trade details to the clearing corporations, cutting out the uninvolved individual at the BD. However, an individual at the clearing corporation prepared the data for the contract sheets to compare the sell side and the buy side, and the process was still riddled with errors. Eventually, the modern order match systems, which eliminated these problems and many of the resulting errors, were adopted. Weiss (2006) estimates that with these improvements in the processing, 99% of trades will go through both the clearing corporation and the BD firms without human intervention.

Netting

After comparison, NSCC nets trades. Netting drastically reduces the number of receives and deliveries between firms. All trades on a particular day in a particular security vary only in the prices at which they were executed, or the contract prices, and the size of the trade, or the number of shares. The contract prices are observed and recorded in the market. The clearing corporation removes the price differences through the use of the Clearing Cash Adjustment (CCA). The clearing corporation chooses a uniform settlement price for all trades that occurred that day. The settlement price could be any reasonable price, such as the first, last, or average price of the day. As opposed to the contract price, the settlement price is not reported to the market; instead, it is used internally to transfer money between members of the clearing corporation with open trades. The settlement price homogenizes trades, or makes them the same. It allows every party that traded in that security on that day to trade share-for-share at the settlement price, while the CCA allows for different contract prices.

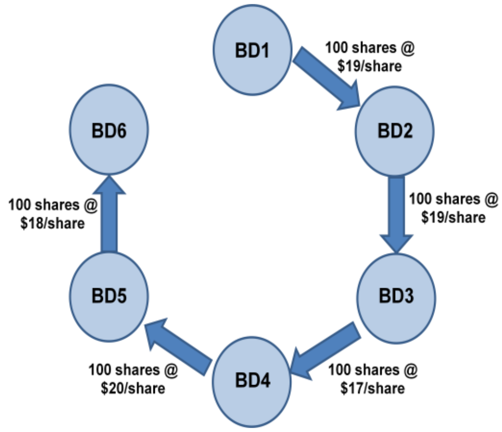
Consider the simplified situation in Figure 2 that shows all trades in Stock X on a particular day, which is based on a similar example by Weiss (2006). Assume only six BDs trade on the current day; ignore commissions and taxes. Without netting, the five trades require five receives and five delivers interfirm, meaning between BD firms. With

Stock X Transactions Today (T)

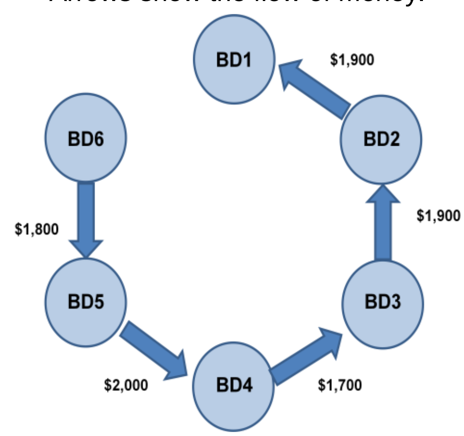
BD	# shares purchased	Contract Price	# shares sold
BD1		19	100
BD2	100	19	
BD2		19	100
BD3	100	19	
BD3		17	100
BD4	100	17	
BD4		20	100
BD5	100	20	
BD5		18	100
BD6	100	18	

A. Before Netting

All Trades
Arrows show the flow of shares.

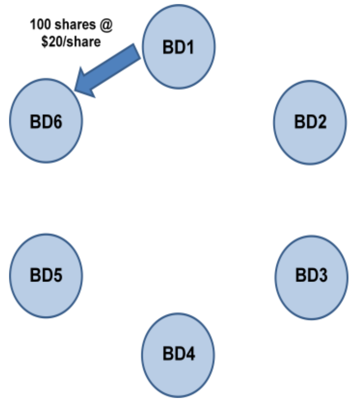


Financial Obligations
Arrows show the flow of money.



B. With Netting

Netted Trades
Arrow shows the flow of shares.



Financial Obligations
Arrows show the flow of money.

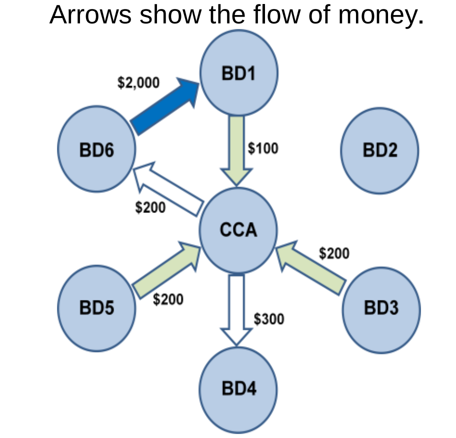


Figure 2. Example of netting decreasing receives and delivers.

netting, the number of interfirm receives and delivers is reduced to one receive and one deliver. The reduction is the result of intrafirm netting, or matching receives and delivers between the clients at a particular BD firm. The remaining obligations are fulfilled by transferring CCA money through the clearing corporation.

For example, BD2 had two clients trade in Stock X today. Although they did not trade with one another, their positions offset one another at the firm. If both investors keep their stocks registered in street name, then there is no transfer of ownership on the issuer's books. The stock remains registered to BD2, who is responsible for recording the transfer of ownership to the new owner on his firm's books. The same intrafirm netting occurs for BD3, BD4, and BD5. Whereas both clients at BD2 had the same contract price, the clients of BD3, BD4, and BD5 had different contract prices. Thus, they also need to move money between clients' accounts to complete the trade.

Netting leaves only one interfirm transfer of securities at the settlement price between BD1 and BD6 that will occur on T+3. In essence, BD1 delivers a round lot, or 100 shares, of Stock X to BD6 for $2,000 on the settlement day. Note, too, that the clients of these BDs did not trade with one another, but under the netting process, these BDs had nonzero net positions in the security on the current trading day.

Notice that the settlement price on the current day is $20. Therefore, BD1 pays $100 in CCA to the clearing corporation today. This is because the settlement price is $20/share; for 100 shares, the selling BD will receive $2,000 at settlement. However, at a contract price of $19/share, the selling BD should receive only $1,900. To correct for this, he pays the difference of $100. Similarly, both BD3 and BD5 pay $200. BD2 has no monetary transfer. BD4 is paid $300, and BD6 is paid $200. The sum of the amounts paid ($500) by BD1, BD3, and BD5 is exactly equal to the sum of the amounts paid ($500) to BD4 and BD6. According to the DTCC, netting reduces financial obligations in dollars by over 95% on average.

At this point, the clearing corporation acts as a central counterparty (CCP) to both sides of the trade by taking its place between the buying and selling firms. NSCC guarantees settlement of all transactions entered into its netting system; it takes on the risk associated with the buyer's credit and with the seller's delivery. If either the buyer or seller to the trade fails, NSCC assumes the obligations of that party and attempts to complete open receives or delivers via market action. However, the time frame in which the outstanding obligation is fulfilled is not guaranteed by NSCC. The assurance is only that the obligation will be carried out if a firm fails.[24]

Both NSCC and DTC are subject to credit risk when NSCC guarantees both sides of the trade. DTCC takes many steps to alleviate this risk. In order to become members of the clearing corporation, participants have to meet outlined financial standards.

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[24] This is based on www.dtcc.com/news/press/releases/2006/finnerty.php.

Established members must also comply with financial standards to maintain membership; the clearing corporation monitors the financial position and trading activity of members. It obligates them to mark outstanding positions to market on a daily basis. Additionally, members of DTCC are required to have a minority interest in the firm by holding shares of preferred stock; this helps to align the interests of the members with the performance and sustainability of DTCC. Finally, all members must deposit participant funds with the clearing corporation. These deposits include some combination of cash, marketable securities, and letters of credit.

The participant's clearing fund account provides a cushion of protection to the clearing corporation in the event that a participant goes out of business. It also allows the firm to meet its daily requirements for settling trades and for margin obligations. The amount of this collateral depends on the BD's level of trading. The clearing fund is composed of two parts. The first part is static; since the amount does not change much over time, BDs often meet this requirement by depositing U.S. Treasury bills. The second part is dynamic, changing daily based on current settlement needs. BDs meet this requirement by depositing a bank's letter of credit, which guarantees the bank is willing to lend a certain amount of money on demand. Therefore, the BD does not have to obtain financing on a daily basis. The clearing corporation uses the letter of credit to obtain the funds necessary for the BDs daily settlement activity. The BD is charged a nominal commitment fee for access to the credit line apart from use. The actual loan rate is charged on amounts paid to the clearing corporation.

According to the 2008 DTCC Annual Report, NSCC required participants to have clearing fund deposits to meet obligations and liabilities, based on respective activity levels, totaling $36.44 billion at the end of 2008. However, member firms had an excess on deposit at year end of nearly $10.83 billion. Subsequently, total deposits summed to approximately $47.27 billion on December 31, 2008.

DTC intends to stop member transactions that would cause a debit in excess of the total amount of collateral in its clearing funds account. If a member of the clearing corporation becomes insolvent, its account should have enough funds that, if liquidated, these funds would pay for its failed settlement obligations. When a member fails, NSCC can choose to discontinue acting on behalf of the member. The member's obligations are then liquidated, and any deposits for margin, marking to market, and participant funds will be used to complete unsettled obligations and losses. Furthermore, the various subsidiaries of DTCC work together to close out open positions of the failing member. Excess funds are used first, but if the collateral does not cover the balance, then the subsidiaries will follow outlined rules to offset losses with retained earnings of the corporation. Clearly, the outcome depends on the specifics of the case.

This process was used in 2008 to close out obligations of Lehman Brothers Inc., one member that ranked in the top ten for utilization of NSCC and DTC services at the time, as described in the 2008 DTCC Annual Report. The trustee charged with liquidating

Lehman began work on September 19. Lehman failed to settle on September 23, so DTCC subsidiaries stopped acting on the firm's behalf on September 24. DTCC announced that all of Lehman's open positions were closed out by October 30 without any loss to DTCC or the members' clearing funds. While NSCC was able to fulfill its guarantee that all obligations would be carried out if a firm fails, it took just over a month after Lehman first failed to settle for the clearing corporation to provide this service.

Continuous Net Settlement

Before continuous net settlement (CNS), fails stayed open until the selling BD delivered to the buying one. As a result, the number of open fails grew in the 1960s and substantially contributed to the paperwork crisis at that time. The physical transfer of stock certificates prevailed before DTC was created as the central depository. While the Stock Clearing Corporation (SCC), the predecessor of NSCC, informed BDs to deliver stock to buying BDs and to receive stock from selling BDs, only the two sides to the trade knew whether delivery had occurred or failed. These were bilateral obligations, meaning that the party waiting to receive delivery would only be satisfied when delivery was fulfilled by the specific party from the trade on that particular day.

Fails to deliver are the defining feature of the CNS process. CNS occurs when fails to deliver are rolled into the next day's settlement trades. If net settlement were not continuous, then fails would remain outstanding for longer on average because the fail would become a bilateral obligation. However, in CNS, the fail is not a bilateral contract. Often, a particular fail to receive on one day will be fulfilled soon after, even the next day. This may be accomplished either by intrafirm netting or by the NSCC's policy of filling the oldest receive positions first, which essentially transfers the fail to another BD. When one BD fails to deliver securities, the fail roles forward onto the next day's settlement schedule as an open position at the prior day's settlement price. The position is marked to market daily as long as it is open. For regulatory reasons, fail positions are called open trades.

Rolling the previous day's fails onto today's settlement schedule both lowers the number of open items that can be outstanding at any point in time and allows open items to reflect current market value by marking open fail positions to market. Consider the netting example at time T from Figure 2 again. Suppose that BD1 fails to deliver 100 shares of Stock X to BD6 on the settlement date, at T+3. Under CNS, the fail, or open position, would roll forward to T+4 for netting.[25]

Figure 3 gives an example of CNS. (A) shows the open positions from T after all trades have been netted from Figure 2. The contract price is replaced with the settlement price

[25] Throughout the discussion, the "T+x" notation refers to the original trade day from the example in Figure 2 plus x business days.

A. Open Positions in Stock X on T after Netting

	BD	
# shares purchased	Price	# shares sold

	BD1	
	20	100

	BD6	
100	20	

On T+3, BD1 fails to deliver 100 shares at the settlement price on T of $20/share to BD6.
The fail rolls to T+4.

B. Stock X Transactions on T+4

	BD2	
	18	100
100	19	

	BD4	
	19	100
100	20	
100	21	

	BD5	
	21	100
100	18	

	BD6	
	20	100

Without CNS, netting would result in one deliver obligation from BD6 to BD4.

C. Open Positions in Stock X on T+4 for Netting with CNS

	BD1	
	20	100

	BD2	
	18	100
100	19	

	BD4	
	19	100
100	20	
100	21	

	BD5	
	21	100
100	18	

	BD6	
	20	100
100	20	

The open position rolled forward from T+3 is highlighted.

D. Open Positions in Stock X on T+4 after Netting

	BD1	
	20	100

	BD4	
100	20	

The settlement price of $20 on T+4 is reflected after netting.

Figure 3. Example of fails rolling forward under CNS.

on T after the CCA is paid. Remaining obligations from this day are for BD1 to deliver 100 shares of Stock X to BD6 in exchange for $2,000 on T+3. When BD1 fails to deliver, no stock or money changes hands through the clearing corporation.

The trades in Stock X that occurred on T+4 are shown in (B). Without CNS, the fail would remain a bilateral agreement between BD1 and BD6 and would not appear as an open position. Netting would occur entirely intrafirm for BD2 and BD5. BD4 would net two of its trades internally. The net transfer of stock from this day would be for BD6 to deliver 100 shares of Stock X to BD4 on T+7. Yet, as a consequence of BD1 failing to deliver to BD6 on T+3, BD6 might fail to deliver to BD4, exacerbating the problem. Conversely, with CNS, the failed delivery rolls onto T+4's open positions at the settlement price from T for netting, as shown by the highlighted entries in (C). Now, netting occurs entirely intrafirm for BD2, BD5, and BD6 because each has offsetting transactions within the firm that are netted against one another. Therefore, BD6's T+3 fail to receive is fulfilled through intrafirm netting on T+4.

As shown in (D), after BD4 nets two of its trades internally, the remaining obligations on T+4 are for BD1 to deliver 100 shares of Stock X to BD4 for $2,000 on T+7. Delivery is at the T+4 settlement price of $20/share; coincidentally, this is the same as on T. If BD1 delivers on T+7, there is no further open position. If BD1 does not deliver, its fail to deliver and BD4's fail to receive will roll forward as open positions on T+8. A fail to receive can be thought of as an accounts payable since the shares have not been received and payment has not been made. The purchasing BD does not pay for the shares until received; however, the BD's client has generally already paid for them and is not notified of the failed delivery.

In other words, the purchasing BD gains the float until the position is fulfilled, which is a benefit to him because he can earn interest on the funds that he debits from his client's account on the settlement date. If the client makes the purchase from a cash account, his BD earns interest on the total price of the transaction. If the client makes the purchase from a margin account, the BD charges the client interest on the loan. He also earns interest on the portion of cash put up by the client, which is in place of any interest that he could have earned from loaning the stock had it been delivered. The client does not benefit from this situation, but it is not detrimental to him under normal circumstances, either. It could be problematic, however, if a major brokerage firm or clearing corporation became insolvent before the stock was delivered. In times of crisis, buyers may anticipate extended settlement periods associated with failed delivery and discount security prices accordingly, which would decrease returns to the seller. Buyers may offer lower prices to extract some of the benefit that their BDs obtain from failed deliveries. This would signal a lack of confidence in financial institutions, like a clearing corporation or one of its major member firms, to fulfill obligations to deliver securities in a timely manner.

Since NSCC acts as CCP and nets trades using CNS, BDs with net positions to buy or sell cannot accurately identify the opposite party to the trade. In other words, net buying BDs do not know with certainty which selling BD is going to deliver securities to it at settlement, and net selling BDs do not know which buying BD will pay at settlement. It does not have to be, and likely is not, the party with whom the BD traded. In the examples above, BD1 originally sells to BD2 in a trade executed on day T. Yet, in the first case in Figure 2, BD1 is scheduled to deliver shares to BD6. After BD1 fails to deliver to BD6 on T+3, Figure 3 shows that BD1 is supposed to deliver shares to BD4.

There is a difference between a BD firm failing to deliver and the client of a BD failing to deliver. If a BD fails to deliver securities, he should deliver as quickly as possible. If a BD fails to receive securities, the open position is marked to market to minimize risk for the CCP by allowing clearing fund deposits to adjust and compensate for changes in security values on a daily basis. On the other hand, if a client breaches his obligation, the BD must still fulfill the commitment. In other words, if a client fails to deliver a security or to make a payment to his BD, the BD is not excused from delivering the security or the cash to the opposing BD with whom the trade was made. This represents risk to the BD and explains why BDs have the authority to liquidate other assets in a client's account to meet settlement obligations.

Infrequently, a client may enter into an equity transaction and find himself in a situation beyond his control that prevents him from satisfying his obligation in the trade by the settlement day. The client may be unable to pay for the purchase of a security or unable to deliver to the buyer. Weiss (2006) points out a grace period after the settlement date that allows the client to remedy the situation under extreme circumstances. Clients' trades are supposed to be paid for fully by settlement day but must be paid for no later than two business days after that. After two business days, the BD may request an extension for the client from the NASD's regulatory division; each client is allowed up to five extensions per year. If granted, the client is given additional time. If not, the BD must close out the transaction. The BD liquidates, or 'sells out,' the purchased security if the client fails to pay for it, and the firm 'buys in' the security for an unfulfilled sale. Generally, the BD is fulfilling the obligation at a loss and charges the difference to the client.

Settlement

At this point, NSCC has compared and netted trades. The comparison process confirms trade details. The netting process minimizes the number of interfirm receives and delivers by pairing off transactions within a firm. Through CNS, open transactions are rolled into the next day's trades and netted intrafirm again to minimize fails.

Next, transactions are ready for the settlement cycle. In the current T+3 system, the actual settlement cycle starts the evening before settlement, on T+2. This night cycle, called PDQ for “pretty darn quick,” consists of an exchange of information between DTC and NSCC and embodies the majority of settlement. NSCC prepares a projection report that shows trades pending settlement, consisting of all of the net securities positions that are due to be settled. Net sellers deliver securities, while net buyers receive securities.

Early in the evening of T+2, BDs tell DTC which securities can and cannot be used for settlement on T+3. Some securities are not available for settlement because they are “locked up in seg” under the segregation requirement of SEC Regulation T. This dictates that all securities in cash accounts and a portion of those in margin accounts must be held or controlled by the firm acting as custodian of those accounts at all times. DTC notes the quantity of each security that is available for settlement at each BD.

Later in the evening of T+2, NSCC tells DTC which BDs are net sellers and how many shares they owe. Next, DTC compares the quantity of shares each seller owes to the quantity the seller has available for settlement. If there are enough shares to fulfill the entire obligation, that quantity is transferred out of their account electronically. Otherwise, the shares available for settlement are taken for partial delivery. Rather than crediting the net buyers directly, DTC credits the securities to NSCC’s omnibus account. Then, NSCC distributes the shares to net buyers in chronological order with the oldest receive position filled first. This concludes the PDQ cycle.

On the morning of T+3, the mainline cycle begins. NSCC produces another projection report that shows trades still open for settlement and trades that are due to settle the following day, on T+4. Money is paid to net sellers as buying BDs give orders to their settling banks to send funds.

Timeline for the Settlement Cycle

The settlement cycle starts on the trade date with comparison of trade details. As submitted trade details have already been confirmed by both BDs, the NSCC’s resulting report signifies that the trade is now moving through the processing stream. At midnight between T+1 and T+2, netting occurs, and NSCC becomes the central counterparty to all trades. Legally, NSCC does not promise its trade guarantee until 36 hours or more after the trade.[26] On the evening of T+2, settlement starts with the communication between NSCC and DTC in the PDQ. On T+3, net buyers receive confirmation that securities have been obtained through book-entry transfers, and net sellers receive funds via Fedwire.

[26] Source: Donald F. Donahue, CEO and Chairman of DTCC in his October 28, 2009 keynote speech at the DTCC Executive Form in NYC.

Settlement Cycle for Institutional Trades

Large trades made by institutional investors are processed via a different system but on the same timeline. Instead of NSCC clearing these transactions, institutional orders are entered and handled on Omgeo, which is a joint product that combines Thomson Financial's OASYS and DTCC's TradeSuite. This system handles the entire process of the settlement cycle, including transmitting data electronically and book entry settlement. Institutional trades processed in this manner are reported to the market and thus available in the index return data used in this study.

Institutions are commonly represented by a custodian bank, which must be a member of a national depository, like DTC. Institutional trades are settled on a delivery versus payment (DVP) basis. If the institution is buying securities, it pays for the purchase when the securities are delivered to its custodian bank. Similarly, in a sale, money is not exchanged until the institution's custodian bank delivers the sold securities to the opposing party. Delivery is achieved at the depository through a bookkeeping entry. Again, settlement occurs on T+3.

If an institutional investor buys stock and the seller does not deliver it on T+3, then by the DVP process, the institution retains its cash until delivery occurs. This benefits the purchasing institution because the fail extends a forward contract to the buyer. Fails by institutions are not available in the fails data source for this study, discussed in detail below, because the transactions are not processed by NSCC. The available fail to deliver data from the SEC are collected from NSCC's CNS system.

Ex-Clearing

The contemporary security processing system described in the preceding sections attempts to make financial markets safer by reducing counterparty risk. However, some equity transactions are not processed through this system. The SEC defines an ex-clearing transaction as "a sale of a security that clears and settles otherwise than through a designated clearing agency." No data are available relating to the size or scope of this practice.

The DTCC has not been able to track trades or fails in ex-clearing since those transactions are settled outside of its system. Cosgrove (2009), the DTCC's Managing Director of Clearance and Settlement/Equities, describes ex-clearing trades as "managed broker-to-broker using highly manual and error-prone processes, including phone calls and faxes to exchange information to ensure final settlement."

Although there are currently no data available to illuminate how many ex-clearing trades or fails occur, there is a potential solution on the horizon. In late November 2010, the NSCC began testing of Obligation Warehouse (OW), a new system to track ex-clearing.

OW summarizes and discloses trading activity and highlights outstanding fails in the ex-clearing channel. Although OW does not provide the NSCC's trade guarantee, it may alleviate some of the risk of persistent fails in the ex-clearing channel because it may increase transparency. OW allows failed trades to become observable to market participants beyond the two sides of the trade. However, use of this system is not mandatory, and it is unclear whether BDs partaking in these transactions will elect to report to OW.

Prior Studies Relating to Settlement Cycles

Prior empirical studies investigate settlement effects on equity returns. Many are from a previous institutional structure and focus on factors that influence day of the week effects. An early study, French (1980), considers the day of the week effect in terms of calendar time versus trading time. Based on calendar time, Monday returns should be three times on average the return on every other day of the week. Trading time assumptions suppose that returns are dependent on when the markets are open; therefore, the return should not depend on the day of the week. Using the daily S&P composite index from 1953 to 1977, the study finds that neither model is correct. In fact, returns are positive on all days of the week except Monday, when returns are significantly negative. While French (1980) did not consider settlement effects, these surprising results prompted research to provide explanations, and several researchers suggested that the processing of equity securities may clarify these findings.

Gibbons and Hess (1981) use daily data from 1962 to 1978 covering the S&P 500 index and the CRSP value-weighted and equal-weighted indices. Since these indices display autocorrelation, which they attribute to thin trading, they also study the 30 stocks in the Dow Jones Industrial Average. They find strongly negative and persistent Monday returns for equities. They continue their study with Treasury bills to see whether this finding is consistent across other asset classes. Again, they observe low Monday returns for T-bills. They investigate whether settlement can explain the day of the week effect but find no support for this or any other explanation. Yet, their methodology for investigating the effect of payment delay is limited by their inability to obtain daily interest rate data at the time the study was conducted. Also, they do not account for payment delays due to check clearing. They argue that a negative Monday return should be compensated by a Tuesday return that is high enough to outweigh the Monday fall if this effect is the result of settlement. This rationale is unclear and needs further explanation.

Lakonishok and Levi (1982) study daily CRSP value-weighted and equal-weighted index returns from 1962 to 1979. They assume returns are generated according to the calendar time assumption that Monday returns should be three times as large as returns on other days of the week. They discuss how securities are often purchased with checks, forcing the seller to wait an additional business day for the check to clear before using the money. They also discuss how equities settled on a T+4 time frame prior to February 9, 1968 and on a T+5 time frame after that date. They make no adjustment for the settlement period in the T+4 regime because trades on each day of the week settle on the same day of the next week. This is true for all cases except holidays, which they ignore in the T+4 regime. In the T+5 period, they adjust Monday and Friday returns by subtracting and adding two days of interest at the prime rate, respectively; they also account for holidays. Based on this methodology, they do not find that settlement explains the DOTW effect.

DeGennaro (1990) uses CRSP daily value-weighted index data from 1970 to 1982, when the settlement cycle was T+5 and check clearing required an additional business day. He accounts for both settlement and check clearing to model stock returns as a function of payment delays. He finds that buyers compensate sellers for the payment delay at the risk-free rate over the sample period. From 1970-1972, he finds that sellers require a premium of over four times the risk-free rate for the payment delay and suggests that prospective processing errors are costly to fix and delay payment by more than six business days. His study also finds that the day of the week effect still exists when the model controls for the payment delay.

Berument and Kiymaz (2001) use the S&P 500 index from January 1973 to October 1997 to investigate the day of the week effect. Part of their sample period includes the T+3 regime (July 1995-October 1997), but much of their data are from the T+5 settlement cycle system. Furthermore, they make no adjustment for settlement. Instead, they state that their contribution is documenting the day of the week effect using a generalized autoregressive conditional heteroscedastic (GARCH) model, which allows for changes in volatility over time. They confirm that the highest daily returns are on Wednesdays and the lowest daily returns are on Mondays, which is consistent with the results of prior studies.

III. Short Selling, Fails to Deliver, and Regulation SHO

Short Selling

A trader who sells stock that he does not own engages in short selling. A short seller expects the stock price will drop, so he sells the stock at its current price. To make delivery to the opposing party in the trade, he borrows stock. If the price drops, he can buy the stock back at a lower price and replace the borrowed shares. His profit is the difference between the high sale price and the low purchase price minus transactions costs, such as commissions and interest on the stock loan, and minus dividends, if any, that must be paid to the lender of the borrowed stock. If the price rises, in contrast to the short seller's expectation, he can either wait indefinitely for a favorable decline in stock price or buy the stock and realize the loss. There is potential for unlimited loss with short selling since the stock price can, in theory, increase ad infinitum.

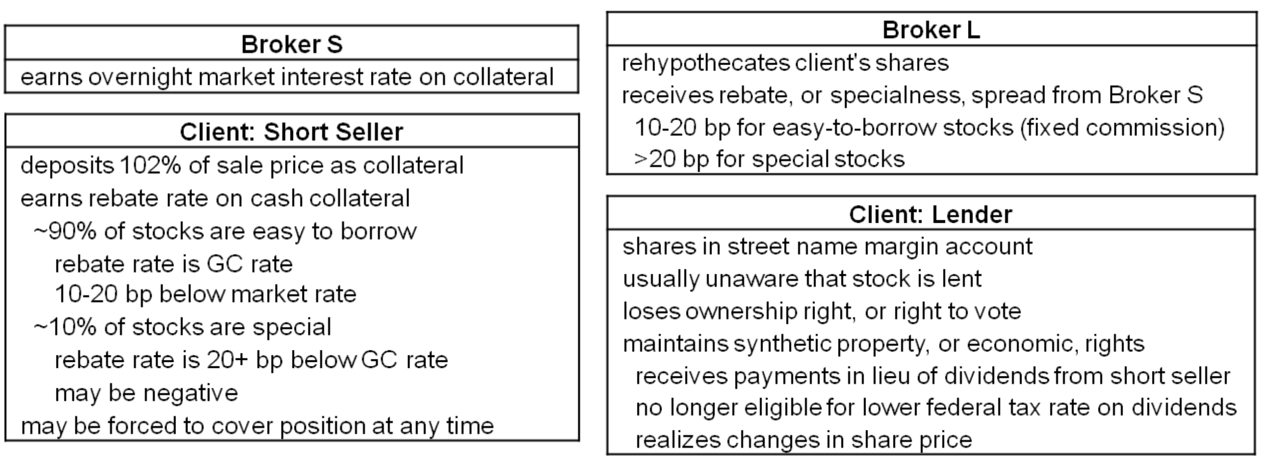
A short seller borrows shares with the help of his BD. The borrowed shares can come from the BD's own trading account, from another one of the BD's clients, or from another BD. Clients purchase securities in cash accounts or margin accounts. Securities are fully paid for in cash accounts. In margin accounts, clients take out a loan from their BD for part of the purchase price. BDs use securities bought by their clients on margin to raise cash for the money lent to those clients through rehypothecation. For shares to be lent from a client's account, they must be held in a street name margin account.

Interestingly, a client rarely knows that his shares have been lent because the BD is not obligated to tell him. Any interest earned from lending the stock is paid to the BD rather than to the client, presumably because the shares are in fungible bulk. In other words, no particular certificate number has been tracked and matched with a particular client. However, BDs track which clients have loaned stock when tax implications are considered. The client's brokerage statement reflects payments received in lieu of dividends, which are not eligible for the federal government's lower dividend tax rate that has been in place since 2003. While BDs may like their clients to believe that tracking whose shares have been lent is too costly and time consuming to do, they already track this for tax purposes. It appears that BDs just do not want to share any revenue that lending generates with their clients.

Short selling increases market liquidity and prevents positive speculation from driving up prices. It also allows for the hedging of a long position. However, short selling is costly and constrained, so the proportion of investors who engage in it is less than that expected in the absence of these costs. Therefore, optimistic investors are overrepresented in a market with constraints on short selling, and they force stock prices to be higher than they would be without short selling restrictions [Miller (1977)]. Different investors face differing constraints to short selling. For example, certain institutional investors, like pension or mutual fund managers, may be forbidden from engaging in short selling by the terms of their governing prospectuses. BDs acting as market makers generally encounter the fewest constraints of all market participants. Individuals, on the other hand, often deal with many constraints to short selling.

Most individual investors bear a number of costs associated with short selling and borrowing stock. The average individual investor does not have access to the proceeds of his short sale. Instead, his BD requires him to keep all of the cash in his account as collateral. Actually, the short seller must supply 102% of the market value of the stock as collateral in most cases, according to Christoffersen et al. (2007). The short seller's BD earns the market rate of interest on the balance. A portion of the interest, referred to as the rebate rate, may be returned to the short seller. Part compensates the stock lender's BD at the rebate spread. Figure 4 shows the features of short selling.

The vast majority of stocks are easy to borrow, so the short seller usually receives a positive rebate rate of around 10-20 basis points less than the current overnight market rate that his BD earns on the deposited balance [Christoffersen et al. (2007) and Evans et al. (2009)]. For easy to borrow stocks, the rebate rate is referred to as the general collateral (GC) rate. The overnight market rate is measured as the effective Fed funds rate. For special stocks, which are difficult to borrow and comprise about 10% of the lending market, the rebate rate is lower than the GC rate and may even be negative, meaning that the short seller pays to cover the higher cost to borrow the stock. Specialness, or the specialness spread, is the difference between the rebate rate on stocks that are easy to borrow (the GC rate) and the rebate rate on the special stock.



GC = general collateral; bp = basis points

Figure 4. Features of short selling.[27]

[27] The lender's economic and voting rights are discussed in more detail below.

An individual investor risks the possibility that, as a short seller, he may have to cover his position earlier than he would like either due to the lender recalling the security or due to a stock price increase. In the first case, the short seller's BD may need to return the borrowed shares to the lender, obligating him to close out the position. In the second case, if the stock price soars, the short seller will receive a margin call from his BD to post the maintenance margin. If the short seller wants to avoid tying up more cash indefinitely in the account, he may sell the securities to close out the position at a loss. Conversely, some powerful, wealthy individual investors may be able to avoid the cost of posting collateral and may be less susceptible to the risk of covering positions earlier than desired. Francis and Ibbotson (2002) state that BDs allow "substantial" individual investors, citing examples such as Rockefeller, DuPont, and Ford, to post less margin than regular clients. The amount may be negotiable, and it may be zero.

Additional restrictions are imposed by regulations that govern short selling. Examples include the previously enforced up-tick rule and Regulation SHO (Reg SHO). The up-tick rule banned short selling at a price referred to as a down tick or a zero tick. A down tick results when a short sale occurs at a price lower than the last sale price. A zero tick results when a short sale occurs at a price equal to the last sale price and when the last sale price is lower than the last different sale price. On the other hand, if a short sale occurs at a price equal to the last sale price with the last sale price higher than the last different sale price, then the result is a zero-plus tick. If the short sale price is greater than the last sale price, this is a plus tick. Under the up-tick rule, short selling was allowed for a zero-plus and a plus tick. This restriction was in place from the 1930s until July 6, 2007. Reg SHO, discussed in detail below, is meant to prevent delivery failures.

In short, BDs require individuals to maintain margin and prohibit the use of the sale proceeds until the position is closed out. Market makers and institutional investors are not subject to these requirements. Francis and Ibbotson (2002) state that institutional investors, giving examples such as Merrill Lynch and Citigroup, can sell short without providing any collateral. Therefore, most short selling is done by stock exchange members. Jones (2007) claims that "NYSE members accounted for about two-thirds of short sales on the NYSE, and the public accounted for the remainder. Specialists, who often sell short to meet public buy orders, accounted for about 40 percent of the members' total."

The proportion of short selling to total trade volume has been increasing over time. Drummond (2006) reports that while NYSE volume has increased 100 times since 1973, short selling has increased even faster, at five times that rate. At a September 2009 Roundtable, SEC Chairman Shapiro acknowledged the "exponential increase in short selling" since the 1990s. In fact, Diether et al. (2009) find that short selling accounted for nearly a quarter of the volume on the NYSE and almost a third of the volume of NASDAQ by 2005.

Short interest is the number of total shares of stock sold short, while the short interest ratio divides short interest by the average trading volume. The existence of short interest may convey negative information, with higher levels implying a more bearish signal. Asquith and Meulbroek (1996) study monthly short interest for firms listed on the NYSE and Amex from 1976-1993 and find that stocks with high short interest levels have significantly worse performance than comparable firms without short interest.

The 2008 DTCC Annual Report shows that members' short positions in securities on deposit at DTC increased from $3.8 million at the end of 2007 to $34.7 million at the end of 2008. Alternatively, open positions at NSCC, which double count by including both the buy and sell sides of the trade, totaled $1.057 billion on December 31, 2008.

Chen and Singal (2003) find that short sellers impact prices systematically by way of speculative short sales that are closed out before the weekend and reopened on Mondays. These actions result in higher prices and returns on Fridays, followed by a reversal on Mondays.

Blau et al. (2006) examine short selling of NYSE-listed stocks across different exchanges, including the NYSE, NASDAQ, and other exchanges, both electronic and regional. They use Trade and Quote (TAQ) data from CRSP for the 64 trading days in the third quarter of 2005. By total volume and short sale volume, they document that around 80% of trades of NYSE-listed securities occur on the NYSE, around 15% on the NASDAQ, and the remainder on smaller exchanges, including Archipelago, Boston, Chicago, National, and Philadelphia. On the NYSE, average total trade volume was approximately 535,000 trades per day, and short sale volume averaged approximately 142,000 trades per day. Overall, the percentage of short sale volume to total trade volume was approximately 27% for their sample of 2,139 NYSE-listed securities.

Generally, the proportion of the exchange's total trade volume to all exchanges' total trade volume was equivalent to the proportion of the exchange's short sale volume to all exchanges' short sale volume. There were two notable exceptions. The ratio of short sale volume on Archipelago versus all exchanges was higher than the ratio of total volume on Archipelago versus all exchanges. The authors presume this is due to the secrecy provided by the electronic medium of the exchange. The opposite was found on the Chicago Stock Exchange, where short sale volume on that exchange relative to all exchanges made up a substantially lower proportion than total trade volume on that exchange relative to all exchanges. Additionally, they find that the smaller exchanges provide an important marketplace for certain securities even if those exchanges do not have substantial activity in the entire spectrum of NYSE-listed securities.

On average, total trades are larger than short sale trades on all the exchanges excluding NASDAQ. On the NYSE, the average total (short sale) trade size was 560 (432) shares. On the NASDAQ, the average total (short sale) trade size was 700 (736) shares. All exchanges showed the well-documented intraday volume pattern for both total and short sale trades. The U-shape reflects more volume near market's open and close, with less volume in the middle of the day. Finally, Blau et al. (2006) show that short selling is more common for higher priced firms, higher volatility firms, and firms with smaller capitalization.

Fails to Deliver (FTDs)

For equities, failure to deliver (FTD) occurs when a seller does not deliver stock upon settlement on T+3. Often, it is the result of a short sale because stock must be borrowed for delivery. However, sales where the seller is long in the underlying security experience infrequent failed delivery as well, particularly if the stock is held in certificate form. Legitimate reasons for FTDs include human or mechanical errors and processing delays. Naked short selling (NSS) occurs when a short seller does not borrow or arrange to borrow shares of stock by settlement, guaranteeing FTD on T+3. All naked short sales result in FTDs, but not all FTDs are the result of naked short selling. For example, a seller (short or long) could make a good faith effort to deliver stock on T+3, but for any one of a myriad of potential reasons, he fails to do so. Consequently, he fails to deliver, but he may or may not be naked short selling.

If a short seller fails to deliver, then the trade remains open and morphs into an undated and unhedged forward contract. Institutions settle on a DVP basis, so no cash is exchanged if no shares are delivered. BDs settle through the NSCC's CNS system; if no shares are delivered in the PDQ cycle, no cash is sent on T+3. If a buyer is an institutional investor, he is aware of the failed delivery and likely considers it a benefit. If a buyer is an individual investor, he is unaware of the failed delivery, and it likely does not benefit or harm him. However, it benefits his BD.

When a stock is sold short, the buyer does not know that he is purchasing from a short seller. In the CNS system, this buyer may not have purchased from this seller, either. Delivery is from an anonymous party as determined by netting that occurs on the trade date. Moreover, an individual investor is given no indication that his BD has not received shares when he buys stock and the seller fails to deliver. The only time that a buyer would know about a failed delivery is if he asks to take possession of the certificate in his own name, rather than maintaining ownership in street name. Otherwise, his statement and the corresponding debit reveal that the trade is complete. In reality, the BD simply labels the account as still requiring delivery [Brooks and Moffett (2008)], and rather than actual shares, the client owns a security entitlement.

The BD can choose to ignore the fail given that his client is oblivious; FTDs that remain outstanding are referred to as persistent FTDs. Or, the BD can demand a forced buy-in. Using a proprietary database for 1998 and 1999, Evans et al. (2009) found that large market makers often fail to deliver, perhaps because there is little risk that they will be forced to do so. In their sample, buy-ins were forced only 0.12% of the time.

The DTCC reports approximately $3 billion in FTDs through the NSCC's CNS system at the end of 2005. Since the DTCC counts both sides of the trade, resulting in double-counting, this is half of the reported $6 billion in FTDs. This figure ignores trades settled via other channels, including DVP settlement of institutional trades and ex-clearing. There is no way to determine the number of fails from ex-clearing [Moyer (2006)].

NSCC runs the Stock Borrow Program (SBP) to make delivery if a short seller is unable to deliver for any reason. Member firms earn interest when they lend stock through this program; firms that want to participate tell the NSCC how much stock is available to lend daily. Although BDs earn interest on shares lent through the SBP, only a relatively small proportion of all failed deliveries are satisfied via the SBP because BDs only have the right to use clients' shares in the SBP if held in street name margin accounts. The SBP, which does not replace members' obligation to deliver securities, fulfilled obligations totaling $171 million on December 31, 2008 according to the 2008 DTCC Annual Report. This left $886 million in failed deliveries on that date.

Regulation SHO

Public campaigns against NSS, claiming that the practice allows malicious investors to drive down the stock price of small companies, led the SEC to adopt Reg SHO. A main goal of Reg SHO is to prevent excessive FTDs from abusive NSS. Abusive NSS occurs when the short seller attempts to manipulate the price of a stock. Further, an abusive naked short seller tries to drive down the price of the stock for his own gain by not delivering the stock after making no attempt to borrow the stock.

Reg SHO compliance began in 2005. To prevent delivery failures, it requires BDs to document locating shares to borrow for delivery within the settlement time frame. This is referred to as the locate requirement. However, BDs are exempt from this rule when they act as "bona-fide market makers." To prevent persistent FTDs, Reg SHO requires BDs, including market makers, to close out positions in threshold securities if they have had open positions in these securities for thirteen consecutive settlement days. Threshold securities have at least 10,000 shares and at least 0.5% of the issuer's total shares outstanding failed to deliver for a minimum of five consecutive settlement days. This is called the close-out requirement. In short, Reg SHO requires all market participants except market makers to locate shares to borrow for settlement. It forces everyone to close out positions in threshold securities that violate its guidelines.

Boni (2006) and Brooks and Moffett (2008) point out that there have not been any legal challenges to the use of the market maker exemption nor any references in the literature of BDs defending their use of it. However, within its first year, the SEC fined some firms for violations of Reg SHO, specifically for incorrectly reporting fails or improperly recording orders as long or short. The NYSE has also fined firms through its regulatory division for Reg SHO breaches. Brooks and Moffett (2008) identify these firms, including Goldman Sachs, Citigroup, JP Morgan, Wachovia, First Clearing, Daiwa, and Credit Suisse. In May 2010, FINRA reported fining both Deutsche Bank Securities and National Financial Services for Reg SHO violations of the locate requirement. The regulatory body found both BDs had bypassed systems that were designed to stop short sales unless the locate requirement was fulfilled.[28]

Market makers may engage in naked short selling for their own profit rather than to merely provide market liquidity. Brooks and Moffett (2008) state that stocks with listed options experience more persistent fails, which suggest that market makers are using their exemption to create arbitrage opportunities by engaging in naked short selling.

Failing to deliver stock at settlement does not automatically violate any laws. NSS is not illegal in all cases, either. If a market maker is unable to borrow shares of a thinly traded, illiquid stock, then he has engaged in naked short selling. This NSS is legal and is a legitimate reason for a FTD under existing law since he is providing liquidity to the market. Reg SHO only asserts that *abusive* naked short selling is illegal as it violates Rule 10b-5 of the Securities Exchange Act. Since the short seller's intent is difficult to prove, this law is challenging to enforce.

The SEC believes that the large and persistent fails tracked on the threshold securities list may indicate manipulative naked short selling in the market. In this sense, Reg SHO sends a clear signal to the market that the SEC is concerned with short selling and wants to provide enhanced disclosure to all market participants. After Reg SHO was implemented, there were numerous companies on the threshold securities list for long periods of time. Moyer (2006) provides the following recognizable examples: Krispy Kreme Doughnuts Inc. (NYSE: KKD), Martha Stewart Living Omnimedia Inc. (NYSE: MSO), Netflix Inc. (NasdaqGS: NFLX), and Overstock.com (NasdaqGM: OSTK).

Reg SHO was not intended to stop short selling; instead, its main goal was to stop problems with short selling. When Reg SHO was formulated in 2004, the most frequent complaint filed with the SEC was "manipulation of securities, prices, or markets," which encompasses abusive NSS.[29] In that year, 1,738 manipulation complaints were filed. When Reg SHO was adopted in 2005, that number decreased by over 50% and fell in the rankings. However, short selling debuted in the top ten complaints in 2006 and stayed there annually through the most recently published list in 2009. In 2008, short selling was the most common complaint, with 1,735 submitted to the SEC. Short selling fell to number two on the list in 2009, below problems with account closings and above securities theft. Based on market participant complaints, it appears that the SEC's oversight has not assuaged the problems.

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[28] The FINRA news release is available at http://www.finra.org/Newsroom/NewsReleases/2010/P121482.
[29] Source: US SEC Enforcement and Market Data 2004, from www.sec.gov.

Even though the SEC was providing oversight with Reg SHO, there was much speculation about the role short sellers played on the demise of firms in the 2008 financial crisis. Many people claim that false rumors were spread to accelerate the downfall of established firms. Some attribute the rumors to short sellers who would profit from a subsequent fall in the stock price. Short sellers were blamed early in the year when Bear Stearns collapsed and later in the height of the crisis when Lehman Brothers fell. Lehman's CEO Richard Fuld claims manipulation by short sellers was one factor that led to the demise of his company (Woellert and Onaran (2008)). Morgan Stanley's CEO John Mack similarly accused short sellers for disturbances to his firm's stock price (Giannone (2008)).

Boni (2006) offers an empirical study prior to the implementation of Reg SHO. She uses proprietary NSCC settlement data of the total number of failed shares and their age in days on three distinct days: September 23, 2003, November 17, 2003, and January 21, 2004. She found that the mean (median) fail is outstanding for 13 (2.9) days for listed stocks with failed deliveries. This result is likely driven by market making activity in illiquid stocks that have fails of over 20 days to several months, which compose roughly 20% of the sample. Although fails are a small proportion of the total number of shares outstanding at only 0.15% of listed stocks, they are pervasive in that approximately 42% of listed stocks had some level of failed deliveries that had persisted for five settlement days or more. She uses institutional ownership, book-to-market, and market capitalization as proxies for identifying stocks that are special, or expensive to borrow, and finds that persistent fails are more likely for stocks that are special. This is because market makers want to avoid paying the rebate spread on special stocks, and they are aware of the low probability that they will be forced to buy-in. Therefore, market makers strategically fail to deliver when it benefits them. Fails are widespread, spanning all markets and industries, and include stocks without listed options.

The SEC started collecting and publicizing NSCC CNS fail data around the time that Reg SHO was implemented. The data report the daily number of outstanding fails for a combination of penny stocks, ETFs, and NYSE and NASDAQ firms; however, the age of the fails is not available. In December 2009 alone, sellers failed to deliver a total of nearly 7.5 billion shares over the 22 different settlement dates. This is an average (median) of 53,614 (766) fails per day per company. Of the 139,283 observations, with one observation per day per company, most (~85%) were for less than 10,000 shares. Still, over 3% of the observations were for more than 100,000 shares failed per company per day, and 779 observations were for more than a million shares failed per company per day.

Brooks and Moffett (2008) examine naked short selling and claim that this practice is both pervasive and problematic to financial markets. As evidence for the frequency of naked short selling, they state that all equity trades failed at a rate of at least 4% in 2004, based on the NSCC processing $130-150 billion of equity trades daily and an average of $6 billion of fails at DTC per day. This measure may serve as a conservative estimate since NSCC netting, the SBP, and ex-clearing may conceal more fails. As an example of how severe naked shorting can be, the researchers assert that total fails in one penny stock, Global Links, Inc., were around 25 times the number of outstanding shares during 2005. They point to dematerialization of securities as a likely cause of naked short selling, and claim, “Since there are no longer certificates requiring transfer, the backroom processes have become more complex and opaque, further contributing to the ease of failing without consequence.”

Critics assert that naked short sellers flood the market with excess supply by not delivering stock; excess supply results from so-called phantom shares and lowers the stock’s market price. By phantom shares, they mean that there are more effective ownership stakes than there would be if delivery had occurred. Similarly, they claim multiplicity occurs when a single share of stock is lent out multiple times because individual certificate numbers are not tracked by BDs or by the centralized system for lending and borrowing stock through DTCC. Furthermore, they maintain that BDs should be tracking voting rights, but BDs do not because they are often the group participating in short selling and failing to deliver. Drummond (2006) and Brooks and Moffett (2008) discuss cases of corporate voting difficulties resulting from short selling.

The NYSE found evidence of universal overvoting of proxies by several of its members. A Securities Transfer Association study investigated hundreds of proxy contests from 2005. All 341 instances showed evidence of overvoting. This occurs because the DTC has BDs collect and report how the owners want to vote on company issues. However, the BDs often send out proxy statements and ballots to more clients than are eligible to vote. Most notably, the owner of stock that has been lent out still receives a proxy when he should not. Also, when a short seller fails to deliver stock, the BD marks a buyer’s account with a stock entitlement, and this client also receives a proxy statement and ballot. Generally, no stock has been borrowed in this case, so this too leads to extra votes. In aggregate, these issues do not always result in too many votes since voting rates are generally lower than 100%. Bethel and Gillan (2002) document 86-89% (87% average) voting turnout for various routine matters in 1998. Extraordinary matters had lower voting turnouts, ranging from 71-84% (76% average). However, when a BD firm receives too many votes, it usually follows an in-house procedure to prorate the votes to reflect the appropriate amount. The result is problematic. Illegitimate votes are counted and may overshadow legitimate ones, and one share may be voted multiple times.

Some industry experts who have overseen hundreds of stockholder votes, including shareholder services consultants, stock transfer agents, and proxy firms, allege that outcomes are affected by overvoting on most significant corporate elections and proposals. Overvoting may be the result of illegitimate votes resulting from failed deliveries, while failed deliveries often result from short selling. Many times, close contests are determined by fewer votes than the amount of outstanding short interest. Drummond (2006) identifies proxy contests at Alaska Air Group (5/17/05), Mony Group

(5/18/04), and El Paso Corp. (6/17/03) as three examples where short sales, which may translate into extra votes, outnumbered the winning votes.

Using a proprietary database containing details on all U.S. equity loans by one large custodian bank from November 1998 to October 1999, Christoffersen et al. (2007) found that borrowing substantially increases on the voting record day in comparison to surrounding trading days. This suggests that traders may borrow shares to influence the outcome of corporate votes. Furthermore, these votes sell for nothing on average; in other words, owners are passing their right to vote to someone else. This proclivity toward vote trading is explained by information asymmetry, proxied by the bid-ask spread. When investors are unsure how to vote, they find that their best interest is served by giving up their right to vote to individuals that know how to vote. Moreover, borrowers drive vote trading. Votes are traded more often for poor performing firms, especially when the outcome is closely contested. Also, more vote trading is related to (lack of) support for shareholder (management) proposals. Christoffersen et al. (2007) conclude that "vote trading may serve the socially beneficial role of incorporating more information into corporate votes."

Alternatively, Hu and Black (2007) argue that vote trading may result in market manipulation by parties with conflicting interests to the long-run owners of a corporation. Short selling and other trading strategies, which have been facilitated by financial innovation and enormous growth in the stock lending market, "decouple" economic ownership from voting rights. The authors provide many examples where hedge funds use shorted stock to increase leverage and expand beneficial ownership through, what they term, empty votes or hidden morphable ownership. Empty votes are votes without economic ownership, which can be obtained by borrowing stock. In the U.S., it is illegal to borrow stocks simply to buy votes under Federal Reserve Regulation T, however. Hidden morphable ownership is unobservable, indirect ownership that provides de facto voting, and it may result from short selling either the target or acquirer in a proposed merger situation.

IV. Model Development

<u>Model A. Immediate Delivery and Settlement</u>

I model the following after DeGennaro (1990). I start with a straightforward model of returns with immediate delivery and settlement. In a world of uncertainty, the expected return on financial assets differs depending on risk. Investors are risk averse, so they will only bear higher levels of risk if they believe they will be compensated with higher returns. BDs acting on the behalf of their clients are assumed to be risk-neutral. Investors maximize expected wealth. There are no opportunities for pure arbitrage. There are no transactions costs or taxes. Investors have homogeneous expectations. A risk-free security exists. Securities are jointly normally distributed. Shares are infinitely divisible. There is a fixed security supply. There are no margin requirements.

At the beginning of a one-period model, the expected price of the stock at the end of the period is equal to the observed price compounded continuously at the expected total rate of return on the stock less the expected dividend yield.

$$(1) \qquad E_{t-1}P_t = P_{t-1} * exp[E_{t-1}R_t - E_{t-1}d_t]$$

Taking logs gives:

$$(2) \qquad \ln{(E_{t-1}P_t)} = \ln(P_{t-1}) + [E_{t-1}R_t - E_{t-1}d_t]$$

Rearranging gives:

$$(3) \qquad E_{t-1}R_t = \ln\frac{E_{t-1}P_t}{P_{t-1}} + E_{t-1}d_t$$

Assuming rational expectations means:

$$(4) \qquad R_t = E_{t-1}R_t + e_t$$

or

$$(5) \qquad R_t = b_0 + e_t$$

where

$$b_0 = E_{t-1}R_t = \ln\frac{E_{t-1}P_t}{P_{t-1}} + E_{t-1}d_t$$

Note that dividends at t are known at t-1 as they are announced by the board of directors of the issuing firm prior to the payment date. Thus, $E_{t-1}d_t = d_t$.

Equation (5) models the expected long-run average total return, which is the sum of the price appreciation and the dividend yield, on all stocks as a constant value of b_0. Over time, the actual return at time t deviates from this long-run average by the error term, e_t. The value of b_0 is expected to be positive and approximately equal to 0.04% over the period from June 7, 1995 to December 31, 2009. This estimate is based on the average of the value-weighted index return including distributions from CRSP over the sample period.[30]

Note that b_0 measures the business, as opposed to calendar, day average expected intrinsic total return. I assume investors trade and settle only on non-holidays Monday through Friday; they are unable to trade on Saturdays and Sundays. The return here is limited to the available holding period over business, or trading, days. So, b_0 estimates the average expected true return for a trading day. Currently, this model follows the familiar trade day hypothesis, which presumes that each trading day should have the same return on average.

French and Roll (1986) show that most new information arrives during trading hours. More variance in NYSE and AMEX daily returns from January 1963 to December 1982 occurs during exchange trading hours as opposed to non-trading hours. They attribute this difference in volatility to a small impact from trading noise (4-12%) produced during trading hours and to a large impact from information arrival, specifically private information. While they study volatility rather than returns, their conclusions that most new information arrives during trading hours may support the trade day hypothesis. If stock prices reflect new information, then prices should change mostly when new information arrives in the market. French and Roll (1986) show that information arrival occurs mostly during business hours. Therefore, prices, and hence returns, should be different on trading versus non-trading days. On average, the return on trading days should be greater in absolute value. Prices should change less, and returns should be closer to zero for non-trading days, which are usually weekends, when less information arrives in the market.

According to the alternative calendar time hypothesis, each calendar day should have the same return on average, so Mondays should exhibit average returns that are about three times the average return on other days of the week. In the absence of delays and holidays, Monday has the longest holding period of three days, and all other business days have the same holding period for daily returns of one day.

In order to test whether the data fit the calendar time or the trade day hypothesis, I model the expected total rate of return, $E_{t-1}R_t$, as a function of the calendar day return, CDR_t, times the number of days in the holding period, n_t.

$$E_{t-1}R_t = E_{t-1}(CDR_t * n_t) \qquad (6)$$

[30] See the results section (VI.) for more details.

I restrict the daily return to be constant across calendar days, $CDR_t = CDR$.

The number of days in the holding period is known with certainty. For example, in weeks without holidays, there are three days in the holding period for a Monday return since P_t is the price on Monday and P_{t-1} is the price on the preceding Friday. All other trading days in weeks without holidays have one day in the holding period. Therefore, $E_{t-1}n_t = n_t$.

Thus,

$$(7) \qquad E_{t-1}R_t = CDR * n_t$$

Assuming rational expectations means:

$$(8) \qquad R_t = E_{t-1}R_t + e_t = CDR * n_t + e_t$$

or

$$(9) \qquad R_t = b_0 * n_t + e_t$$

The b_0 coefficient will estimate the calendar day return. By estimating equation (9), I will check whether there is a constant trade day return as the trade day hypothesis purports. If I fail to reject that b_0 is zero, then there is no support for the calendar day hypothesis.

Model B. Three Business Day Settlement Cycle

If settlement issues matter, true prices, in the absence of payment and delivery delays, are unobservable. A payment delay occurs for all trades under the current settlement cycle. The buyer benefits from a payment delay, during which time he can earn interest on the cash needed to settle the trade. Since the seller has no analogous opportunity, the cost of the payment delay should be reflected in equity prices, making observed prices higher than true prices in the absence of payment delays. Here, I attempt to measure the effect of payment delays on observed prices.

I consider a model of returns with delayed settlement. Since 1995, equity securities in the U.S. have cleared on a T+3 system, meaning that money and securities actually trade hands three business days after the trade date. On the trade date, the price is agreed upon by the parties to the trade. Both parties are contractually obligated to fulfill their end of the agreement by delivering either money or securities on the third business day following the trade.

Due to this delay, it is possible that the observed price (P_t) is equal to the true or intrinsic value of the security (P_t') plus an adjustment for the delay in payment that results from security clearing and settlement procedures.

The rationale behind this adjustment stems from the fact that after a trade is executed, the buyer gets to continue using his money for three additional business days, which is normally three to six calendar days. On the other hand, the seller can no longer use his stock.[31] He sees no gain if the price rises after the trade since he is locked into the contract price. The value of his claim on the stock does not appreciate, and he earns no interest between the trade date and the settlement date. Sellers realize this payment delay exists. Presumably, knowledgeable investors know what this delay is worth and build a premium into prices to compensate the seller.

Compensation may be at the risk-free rate of return, or it may be higher given that complications can occur during the settlement cycle. If it is higher, the resulting risk premium may indicate sellers' confidence – or lack thereof – in their probability of getting paid on time. One explanation for a risk premium may be that there is a possibility that payment will be delayed by more than three business days due to errors, and sellers require return in excess of the risk-free rate when these errors are costly to detect and fix. Such legitimate errors with a positive probability of occurrence include human or mechanical errors and processing delays. Another explanation for a risk premium is that a buying firm could disappear or suffer severe financial difficulties in the intervening period between trade and settlement. During the 2008 financial crisis, financial institutions were closed or sold quickly, often over the weekend. This example illustrates the possibility that longer delays may occur.

If buyers compensate sellers for payment delays, the observed price (P_t) is equal to the true value of the stock in a world without payment delays (P_t') compounded by the return for the waiting time over the clearing and settlement period. This suggests compensation from the buyer to the seller for the privilege of holding the cash for three business days after the trade date.

$$(10) \qquad P_t = P_t' * exp\left[\sum_{i=1}^{D_t} c_{i,t}\right]$$

Here, D_t is the number of calendar days from the day of the trade, at time t, until the cash and security are delivered to the seller and buyer, respectively. In other words, it counts the delay in payment in calendar days, as opposed to business days, between the trade and settlement. The compensation measure, $c_{i,t}$, is daily compensation determined on the trade date for each day in the settlement delay period. Since $c_{i,t}$ is determined at time t when the trade is executed, it is not an expected value. The term in brackets is the aggregate compensation that is implicitly agreed upon at the time of the trade.

[31] The seller receives any dividends paid during the three business day settlement period, as long as he was the holder of record on the date specified by the company for the dividend. The buyer never receives dividends paid during the three business day settlement period.

Equation (10) allows a different compensation rate for each calendar day of the waiting period. For example, if a trade occurs during a week without a holiday and on either a Monday or Tuesday, D_t is equal to three since the trade will settle in three calendar days. If a trade occurs during a week without a holiday and on a Wednesday, Thursday, or Friday, D_t is equal to five since the trade will settle in five calendar days (three business days plus two additional days from the intervening weekend.)

For a Monday trade, the term in brackets is the sum of (1) the compensation on the first calendar day in the settlement period (Tuesday) as determined on the trade date (Monday), plus (2) the compensation on the second calendar day in the settlement period (Wednesday) as determined on the trade date (Monday), plus (3) the compensation on the third and final calendar day in the settlement period (Thursday) as determined on the trade date (Monday). See all possible settlement schedules in Appendix A.1.

This equation is also valid at time t-1.

$$(11) \qquad P_{t-1} = P'_{t-1} * exp\left[\sum_{i=1}^{D_{t-1}} c_{i,t-1}\right]$$

Next, I substitute (10) and (11) into (1), which is the original one-period model where the expected price of the stock at the end of the period is equal to the observed price compounded continuously at the expected total rate of return on the stock less the expected dividend yield.

$$(12) \qquad E_{t-1}P'_t * exp\left[\sum_{i=1}^{D_t} c_{i,t}\right] = P'_{t-1} * exp\left[\sum_{i=1}^{D_{t-1}} c_{i,t-1}\right] * exp[E_{t-1}R_t - E_{t-1}d_t]$$

As discussed earlier, the compensation measures for the payment delays are determined on the trade date for each day in the settlement period. Since the aggregate compensation is implicitly agreed upon at the time the trade is executed, it is not an expected value.

Taking logs gives:

$$(13) \qquad \ln\,(E_{t-1}P'_t) + \left[\sum_{i=1}^{D_t} c_{i,t}\right] = \ln\left(P'_{t-1}\right) + \left[\sum_{i=1}^{D_{t-1}} c_{i,t-1}\right] + E_{t-1}R_t - E_{t-1}d_t$$

Rearranging gives:

$$(14) \qquad E_{t-1}R_t = \ln\frac{E_{t-1}P_t^{'}}{P_{t-1}^{'}} + E_{t-1}d_t + \left[\sum_{i=1}^{D_t} c_{i,t}\right] - \left[\sum_{i=1}^{D_{t-1}} c_{i,t-1}\right]$$

The compensation measure is assumed to be uncorrelated with the intrinsic price of the security; if not, then the result may be biased and inconsistent coefficient estimates in the model due to errors in variables. Equation (14) says that the expected total rate of return on the stock at time t is equal to the expected price appreciation of the intrinsic value of the security in a world without payment delays plus the expected dividend yield plus the differential, agreed upon compensation for payment delays between the settlement periods.

Redefining the terms in (14) to simplify gives:

$$(15) \qquad E_{t-1}R_t = E_{t-1}r_t + \Delta F_t$$

where

$$E_{t-1}r_t = \ln\frac{E_{t-1}P_t'}{P_{t-1}'} + E_{t-1}d_t$$

and

$$\Delta F_t = \left[\sum_{i=1}^{D_t} c_{i,t}\right] - \left[\sum_{i=1}^{D_{t-1}} c_{i,t-1}\right]$$

On the right hand side of (15), the first term ($E_{t-1}r_t$) is the total expected return on the security in the absence of payment delays. The second term (ΔF_t) is the change in the compensation factor between settlement periods for trades at time t and at time t-1. The expected observed total return on the security in (15) is different from the expected true total return – the intrinsic capital gains yield plus the dividend yield – unless the compensation factors over both respective settlement periods are equal to one another.

Table 4 shows one approach to compute ΔF_t, the compensation differential for payment delays, by trade date during non-holiday weeks.[32] This method uses rates that are observable to the investor on the day of the trade and adjusts them for the length of the settlement period. For a Monday trade, the differential compensation is measured as three times the risk-free rate on Monday (since there are three calendar days in the settlement period on Monday trades) minus five times the risk-free rate on the prior

[32] Phillip Daves suggested this method.

Table 4. First approach to differential compensation for payment delays.

Day of Trade	ΔF_t = Risk-free rate on…
Monday	(Monday x 3) – (Friday x 5)
Tuesday	(Tuesday x 3) – (Monday x 3)
Wednesday	(Wednesday x 5) – (Tuesday x 3)
Thursday	(Thursday x 5) – (Wednesday x 5)
Friday	(Friday x 5) – (Thursday x 5)

Note: This method to compute differential compensation for payment delays during weeks without holidays is based on rates that are observable to the investor on the day of the trade.

Friday (since there are five calendar days in the settlement period on Friday trades), which is the trade date preceding Monday.

DeGennaro (1990) employs a different method to compute the differential compensation for payment delays using the daily rates for each day in a particular settlement period. Consider the following example, and see Appendix A.2 for a detailed description by day of the week. The return on a Tuesday in a week with no holidays partly depends on the difference between the compensation on Friday and Tuesday. This is because the payment delay on Tuesday (time t) includes settlement over Wednesday, Thursday, and Friday. The payment delay on Monday (time t-1) includes settlement over Tuesday, Wednesday, and Thursday. Therefore, the difference between the two settlement cycles is (Wednesday + Thursday + Friday) – (Tuesday + Wednesday + Thursday) = Friday – Tuesday. In sum, the expected observed total return on Tuesday will include the expected intrinsic return on Tuesday plus the compensation for payment delay on Friday minus the compensation for payment delay on Tuesday.

Table 5 lists the compensation differentials for payment delays by trade date during non-holiday weeks as derived in Appendix A.2. For a Monday trade, the differential compensation is measured as the payment delay for the Thursday *after the trade* minus the payment delay for the Saturday and Sunday *preceding the trade* as well as the payment delay *on* the Monday trade date. Note that cash is available to the seller on the settlement day. He receives cash on T+3 and can re-invest it on T+3.

Often, expected returns are decomposed into the return for delaying consumption (or the return for time) and the return for taking on additional risk (or the return for risk.) If we assume that all equity transactions clear and settle as they are supposed to, without any risk that they will not settle, then the compensation measures above should be the risk-free return for time for waiting for delivery of cash for securities. In this case, the best measure for a return for time is the risk-free rate. Theoretically, the reason to

Table 5. Second approach to differential compensation for payment delays.

Day of Trade	ΔF_t = Risk-free rate on…
Monday	Thursday – (Saturday + Sunday + Monday)
Tuesday	Friday – Tuesday
Wednesday	(Saturday + Sunday + Monday) – Wednesday
Thursday	Tuesday – Thursday
Friday	Wednesday – Friday

Note: This method to compute differential compensation for payment delays during weeks without holidays is based on DeGennaro (1990) and considers rates on the days in each settlement period.

expect the risk-free rate is that security prices may be considered forward prices rather than spot prices since the transaction is actually settled three business days after the trade date [Gibbons and Hess (1981)]. The forward price equals the spot prices compounded by the risk-free rate of return over the settlement period. I will use the daily effective Federal funds rate as a proxy for the risk-free rate of return.[33]

Prior studies have documented how stock returns vary by the day of the week. The average return on Mondays is lower than the average return on other trading days [French (1980) and Gibbons and Hess (1981)]. While the day of the week effect has been extensively studied in U.S. equity markets, it also exists in other U.S. securities markets (bonds, futures, Treasuries) and in international equity markets [see Berument and Kiymaz (2001)]. If every trade day has roughly the same risk-free rate over short periods of time, then based on the differential compensation for payment delays shown in Tables 4 and 5, Monday should have the lowest return and Wednesday should have the highest return, on average. Tuesday, Thursday, and Friday should be in between.

From (15), assuming rational expectations gives:

$$(16) \qquad R_t = E_{t-1}R_t + e_t = E_{t-1}r_t + \Delta F_t + e_t$$

or

$$(17) \qquad R_t = b_0 + b_1 \Delta F_t + e_t$$

where

$$b_0 = E_{t-1}r_t = \ln \frac{E_{t-1}P'_t}{P'_{t-1}} + E_{t-1}d_t$$

[33] See the results section (VI.) for more details.

Equation (17) states that the observed return is equal to the true return without a payment delay plus an adjustment for the change in the compensation factor between settlement periods plus an error term. For the observed return on U.S. equity securities, I use daily stock market return data, both value-weighted and equal-weighted including distributed dividends, from CRSP during 1995 to 2009.[34]

Scholes and Williams (1977) show that nonsynchronous trading of securities causes daily portfolio returns to be autocorrelated, predominantly at the first lag. Therefore, the error term from (17) may follow a pattern such as a first-order moving average process as shown here, which will be determined empirically.

$$e_t = u_t - \theta u_{t-1} \tag{18}$$

Coefficient Expectations for Model B

Equations (17) and (18) constitute Model B, the model with a three business day settlement cycle. Coefficient expectations are shown in Table 6. DeGennaro (1990) provides empirical evidence for the b_1 coefficient during the T+5 era. Using 1970-1982 data, he finds that buyers compensate sellers for the payment delay at the risk-free rate, supported by this coefficient having a value of approximately one. However, in one

Table 6. Expected signs for the coefficients in Model B.

$b_0 > 0$	estimates daily average expected intrinsic total return for each business, or trading, day on all stocks in the market.
$b_1 = 0$	if settlement issues, specifically payment delays, do not matter; if sellers do not demand compensation for waiting three business days; note that if this is true, then the situation simplifies to equation (5) in a world without payment delays.
$b_1 = 1$	if sellers are compensated for waiting three business days at the risk-free rate of return.
$b_1 > 1$	if sellers demand additional compensation from buyers in excess of the risk-free rate of return; if sellers demand a premium due to potential delays beyond the three business day settlement period; these delays may result from legitimate processing errors that are costly to detect and fix or from financial crises.

[34] See the results section (VI.) for more details.

subperiod (1970-1972), he finds that the premium was over four times the risk-free rate, or b_1= 4.27, which may have been due to sellers demanding a premium for potential costly processing errors that delay payment by more than six business days. I expect to find similar results under the T+3 system. Overall, I expect b_1 to be equal to one. Some subperiods, however, may exhibit higher coefficients.

I assume the two day grace period that buyers may be entitled to, as described in Weiss (2006), does not matter because it occurs infrequently under extreme circumstances. If this assumption is incorrect, my results will be affected because the actual payment delay will be miscalculated. The settlement period will be T+5 rather than T+3. If the two day grace period does matter, then the b_1 coefficient will be less significant than if it does not matter.

Payment Delays on the Street Side Versus Customer Side

The street side refers to the part of the trade between two opposing BDs, whereas the customer side refers to the part of the trade between the BD and his client.

Payment delays matter to the customer. Every investor experiences a wait of three business days before settlement. The seller wants compensation for waiting for the trade to settle since the buyer gets to use his cash for an additional three business days. The marginal seller will recognize this and demand a premium in the price of the security at the sale.

Payment delays only matter to the street side in the sense that clearing corporation participants must post more collateral in the form of clearing funds than if the length of the settlement cycle were shorter. The financial industry publicly discussed decreasing the length of the settlement cycle up until 2002; at that time, the conversation was dropped. This cost, therefore, is preferable to the cost of shortening the cycle. Post-trade processing may affect security prices in that, for example, NSCC participants paid approximately $0.003 for each side of a trade on average in 2008. However, a cost to clear and settle would exist with or without a payment day.

Beyond payment delays, BDs and their clients may price securities based on the possibility that the buyer will fail to pay for the securities either on time or ever. Sellers may be concerned that the buyers will not pay for their securities; however, only major problems would cause this to happen for trades that are processed through the central clearing corporation.

If an individual buyer fails to pay for his purchase on the customer side of the trade, this does not excuse his BD from completing the commitment. In other words, if the individual trader cannot pay, it is his BD's problem. The customer's inability to pay independently does not affect the opposing BD or the individual seller and would not find its way into the trade price. Instead, the client's credit risk to his BD would manifest itself in the form of the buyer's BD charging his client penalties or fees, passing on realized losses, imposing trading activity limits, or liquidating other assets.

On the other hand, if the buyer's BD firm has liquidity and solvency problems, then it may fail to pay for its client's purchase on the street side of the trade. This scenario suggests the BD's firm cannot meet its short term financial obligations, and the clearing agency did not foresee the problem. This situation is unlikely, but the dissolution of Lehman Brothers suggests that a major market participant could disappear quickly. When Lehman collapsed, there was much fear in the market. Nonetheless, the 2008 DTCC Annual Report announced that all of Lehman's obligations were expected to be satisfied without using DTCC's retained earnings or its participants' deposits. The main consequence was that some of those obligations took much longer than usual to be satisfied. This situation, where a major BD firm goes out of business abruptly, leaving its unsettled trades to be closed in a timely and costly manner, may be reflected in security prices. If the marginal seller could sense the impending disaster, he would require a higher rate of compensation than the risk-free rate for the standard payment delay because he faces great uncertainty that he will receive payment at settlement. Likewise, the marginal buyer may demand compensation for the likelihood that he will not receive delivery on time in a panicked market, and he will have difficulty either forcing a buy-in for delivery or selling out of the position when he has nothing to deliver.

Model C. Three Business Day Settlement Cycle and Failed Deliveries

The possibility of failed delivery may also affect security prices if market participants expect that sellers will not deliver securities on time. A failed delivery effectively becomes a forward transaction. This generally benefits institutional buyers and the BDs of individual buyers. Therefore, buyers may compensate sellers over the expected extended settlement period. Conversely, individual buyers pay on the original settlement date regardless of when their BDs take delivery of the securities, so these buyers do not benefit from a forward contract and may refuse to compensate sellers for failed delivery. In fact, they may want to split some of the benefit that their BD extracts from failed deliveries and offer lower prices to buy.

Therefore, I next consider failures to deliver. To build this model, I assume there are no short sales restrictions. In addition to payment delays, there is some risk that the seller will fail to deliver the securities, by accident or on purpose, to the buyer. Legitimate reasons for accidental security delivery failure include human or mechanical errors, processing delays, and the inability of market makers to borrow thinly traded, illiquid stock in a short sale. For example, there may be a clerical error when a trade is entered into the DOT, ACT, or Omgeo systems, or an error may exist in the processing instructions. Alternatively, short sellers may strategically fail to deliver on purpose. Boni (2006), using data before the implementation of Regulation SHO, determines that market makers choose to fail to deliver on short sales when it benefits them. In other words, when the cost to borrow stock to deliver a short sale is high, these traders simply do not borrow; the result is a naked short sale. There is a high likelihood that this practice still exists since Regulation SHO exempts market makers from its locate requirements; they are not forced to document that they have located shares to be borrowed and delivered within the settlement time frame like all other short sellers.

If prices reflect the possibility that no securities will be delivered at settlement, or the risk of failure to deliver, then Model B, derived in the last section for the three business day settlement cycle shown in Equations (17) and (18), must be amended further. The observed price (P_t) is equal to the true value of the stock in a world without payment delays or failed deliveries (P_t') compounded by two adjustment factors. The first adjustment factor is the compensation discussed in the preceding model for the payment delay ($c_{i,t}$) from the buyer to the seller. The new, second adjustment factor is the compensation term for the risk of failed delivery from the seller to the buyer. This new factor amends (10) as follows.

$$(19) \qquad P_t = P_t' * exp\left[\left(\sum_{i=1}^{D_t} c_{i,t}\right) + \beta(\Pr(Fail_t))\right]$$

The $\Pr(Fail_t)$ term is a measure of the likelihood of failed delivery. The β coefficient on this term reflects the rate of return for a unit increase in this measure. Buyers may consider greater levels of fails in the market to be beneficial to them since a fail extends the time to settlement. They gain an undated forward contract. Sophisticated buyers recognize this, know when the probability of failed delivery is high, and may be willing to pay a premium accordingly for the benefit. At time T, when a trade is executed, the buyer determines the probability that the transaction will result in a failed delivery on the settlement date at time T+3.

Equation (19) is also valid at time t-1.

$$(20) \qquad P_{t-1} = P_{t-1}' * exp\left[\left(\sum_{i=1}^{D_{t-1}} c_{i,t-1}\right) + \beta(\Pr(Fail_{t-1}))\right]$$

Next, I substitute (19) and (20) into (1), which is the original one-period model where the expected price of the stock at the end of the period is equal to the observed price compounded continuously at the expected total rate of return on the stock less the expected dividend yield.

$$
(21) \quad E_{t-1}P'_t * exp\left[\left(\sum_{i=1}^{D_t} c_{i,t}\right) + \beta(\Pr(Fail_t))\right] = P'_{t-1} * exp\left[\left(\sum_{i=1}^{D_{t-1}} c_{i,t-1}\right) + \beta(\Pr(Fail_{t-1}))\right] * exp[E_{t-1}R_t - E_{t-1}d_t]
$$

Taking logs gives:

$$
(22) \quad \ln(E_{t-1}P'_t) + \left[\left(\sum_{i=1}^{D_t} c_{i,t}\right) + \beta(\Pr(Fail_t))\right] = \ln(P'_{t-1}) + \left[\left(\sum_{i=1}^{D_{t-1}} c_{i,t-1}\right) + \beta(\Pr(Fail_{t-1}))\right] + [E_{t-1}R_t - E_{t-1}d_t]
$$

Rearranging gives:

$$
(23) \quad E_{t-1}R_t = \ln\frac{E_{t-1}P'_t}{P'_{t-1}} + E_{t-1}d_t + \left[\sum_{i=1}^{D_t} c_{i,t}\right] - \left[\sum_{i=1}^{D_{t-1}} c_{i,t-1}\right] + \beta[\Pr(Fail_t) - \Pr(Fail_{t-1})]
$$

Both of the compensation measures – for payment delays and for the probability of failure – are assumed to be uncorrelated with the intrinsic price of the security. Equation (23) says that the expected total rate of return on the stock at time t is equal to the expected price appreciation of the intrinsic value of the security in a world without payment delays or failed deliveries plus the expected dividend yield plus the agreed upon differential compensation for payment delays over the period plus an adjustment factor for the differential probability of fails over the period. The adjustment factor for fails consists of the return due to a change in the probability of failure multiplied by that change.

Redefining the terms in (23) to simplify gives:

$$
(24) \quad E_{t-1}R_t = E_{t-1}r_t + \Delta F_t + \beta \times \Delta\Pr(Fail_t)
$$

where

$$
E_{t-1}r_t = \ln\frac{E_{t-1}P'_t}{P'_{t-1}} + E_{t-1}d_t
$$

and

$$\Delta F_t = \left[\sum_{i=1}^{D_t} c_{i,t}\right] - \left[\sum_{i=1}^{D_{t-1}} c_{i,t-1}\right]$$

and

$$\Delta \Pr\,(Fail_t) = \Pr(Fail_t) - \Pr(Fail_{t-1})$$

On the right hand side of equation (24), the new third term $\beta \times \Delta\Pr\,(Fail_t)$ is the rate of return due to the change in the likelihood of failed delivery between time t and time t-1.

Note that the observed total return on the security is different than the true total return, which is the intrinsic capital gains yield plus the dividend yield, unless ΔF_t and $\beta \times \Delta\Pr\,(Fail_t)$ sum to zero.

As discussed earlier, the expected return includes both return for the time value of money and return for taking on additional risk. If we assume that all equity transactions clear and settle as they are supposed to without any risk that they will not settle, then the compensation measure above for the risk of failed delivery will be zero due to the certainty of the transaction. However, if there is a positive probability that transactions will not settle, then the compensation measure for the risk of failed delivery will affect security prices as sellers extract some return from buyers for the benefit of an extended settlement timeframe.

Assuming rational expectations:

$$R_t = E_{t-1}R_t + e_t = E_{t-1}r_t + \Delta F_t + \beta\Delta \Pr(Fail_t) + e_t \quad (25)$$

or

$$R_t = b_0 + b_1\Delta F_t + b_2\Delta \Pr(Fail_t) + e_t \quad (26)$$

where

$$b_0 = E_{t-1}r_t = \ln\frac{E_{t-1}P'_t}{P'_{t-1}} + E_{t-1}d_t$$

$$e_t = u_t - \theta u_{t-1} \quad (27)$$

Equations (26) and (27) constitute Model C with a three business day settlement cycle and failed deliveries. Equation (26) states that the observed return is equal to the true return without payment delays or failed deliveries plus an adjustment for the change in the compensation factor between settlement periods plus an adjustment for the risk of failed delivery plus an error term. The b_2 coefficient on the differential compensation for failed delivery term estimates the rate of return due to failed deliveries, β. As in (18), equation (27) shows that the error term may follow a pattern such as a first-order moving average process, which will be determined empirically, to model the effect of nonsynchronous trading.

Coefficient Expectations for Model C

The b_2 coefficient estimates an interest rate. Depending on how the market prices fails, the coefficient on the change in the probability of failed delivery, b_2, could take a positive or negative value, or it may be zero. If it is zero, then there is no additional return for an increase in the likelihood of FTDs. If it is positive, then the seller is extracting interest at a rate equal to the magnitude of the coefficient for the higher likelihood of FTDs. If it is negative, then the buyer is getting a discount at a rate equal to the magnitude of the coefficient for the higher likelihood of FTDs.

First, a situation in which b_2 could be greater than zero would be characterized by the fail being resolved to the benefit of the buyer at the detriment of the seller. As discussed earlier, this could happen if market participants interpret that a failed delivery turns a regular transaction into an open-ended forward transaction. Then, buyers compensate sellers; the compensation that sellers demand depends on the expected length of time that the fail will be outstanding. It seems reasonable to expect that sellers would require the risk-free rate over the anticipated extended settlement period. Institutional investors likely benefit from an extension of the payment delay since they do not pay for securities until delivery via the DVP settlement process. However, NSCC's CNS system does not process DVP institutional trades, so the data used to estimate this model does not include this group.

While individual investors do not necessarily benefit from an extension of the payment delay since they pay for securities on settlement, regardless of when delivery occurs, their BDs may profit from failed delivery. In normal circumstances, individual investors are unaffected by failed deliveries, so they may unknowingly pay the sellers a premium if their BD can extract it from them. In other words, if individual investors are uninformed about failed deliveries, then the premium may still exist for these trades because the more sophisticated BDs stand to profit. The individual investor is a price-taker in this situation. The BD not only receives a forward contract from the failing seller, but he also receives cash from his client. So the buyer's BD could be the winner in this situation. If the buyer is a price taker, he may be willing to pay extra for the benefit to his BD and may be forced to do so because of competition.

Next, consider circumstances for b_2 to be less than zero. Again, consider the buyer's BD. He receives cash from his client on T+3 and obtains an extension until he has to pay for the failed delivery. However, if the security is failed because it is on special, or hard to borrow, then the BD loses out on the opportunity to lend the security and make a greater profit from a high specialness spread. As a lender, the buyer's BD would earn a fixed commission (10-20 basis points) plus an extra amount depending on specialness. If this is greater than the market rate, then the buyer's BD is the loser in this situation. If buyers are price takers, then prices may be lower because buyers' BDs may want compensation from sellers for an increase in the probability that sellers will fail to deliver stocks with a high specialness spread.

Less than 10% of securities are on special on average, but failed securities are probably more likely to be on special and thus have the potential for higher profits from lending. The buyer's BD would consider the tradeoff between (1) an extension of the payment delay and the interest earned on his client's cash (i.e., a positive outcome) with a probability equal to the probability of failure versus (2) the loss of potential lending income on special (i.e., a negative outcome) with a probability equal to or less than the probability of failure. When a short seller fails to deliver, he does not earn the rebate rate. If the stock is on special, the rebate rate is low or even negative. Therefore, the short seller may weigh the cost of borrowing shares against the cost of failing to deliver.

Another situation for b_2 to be less than zero could happen in extraordinary circumstances, like periods of financial crisis, if individual investors assess fails with more scrutiny than usual and build a discount into prices. These buyers may refuse to compensate sellers since they do not benefit from a forward contract. Besides, they may require a lower price to acquire some of the benefit that their BD extracts from failed deliveries. This outcome may signal a lack of confidence in a clearing firm or member to fulfill its obligation to deliver securities, not just on time, but perhaps, at any time in the future.

Individual buyers may be concerned that failed shares will negatively affect them. If a client's BD firm, another major clearing firm, or the clearing corporation becomes insolvent during the settlement period, the individual buyer may be unable to turn around and sell an undelivered stock until the original delivery is fulfilled. A buyer may demand a discount at the time of purchase to compensate for the fact that his cash has been exchanged for a security entitlement, rather than a security, and he may have difficulty getting out of the long position in a financial crisis.

Therefore, security prices may be affected by delivery failures even when a clearing corporation, like NSCC, acts as CCP during the netting step of the settlement cycle. In 1995, Adler Coleman Clearing Corporation unexpectedly went bankrupt. According to the 2008 DTCC Annual Report, NSCC stepped in, guaranteed $1.6 billion in pending transactions, and worked with the Securities Investor Protection Corporation (SIPC) to look after the clearing corporation's members through the liquidation process. What would happen if DTCC failed some day? Beyond the risk of DTCC failing, the failure of a major clearing firm, or participant BD firm, could also affect the settlement process, as evidenced with the failure of Lehman Brothers. Thus, if buyers expect systemic problems in the clearing and settlement process, prices may reflect greater discounts for failed deliveries in times of financial crisis.

To summarize, in times of crisis, the individual buyer may realize that the clearing corporation or its members may become insolvent, and his failure to receive shares for his purchase will persist indefinitely. This will make it hard for him to get out of the position for which he has already paid. In this case, b_2 could be less than zero because the buyer demands a discount in the price of the stock on the trade date.

Expectations for the b_2 coefficient in Model C with a three business day settlement cycle and failed deliveries are shown in Table 7. Expectations for coefficients b_0 and b_1 are the same as in the model with a three business day settlement without failed deliveries. Note that if b_2 = 0, then the situation simplifies to Model B shown in equation (17) in a world with a three business day settlement cycle but no failed deliveries.

Table 7. Expected sign for the b_2 coefficient in Model C.

b_2 = 0	if the risk of failed delivery does not matter in pricing equity securities. if there is an offsetting balance between (a) the discount individual buyers demand for failed delivery in times of financial crisis and (b) the premium sellers demand for extending a forward contract.
b_2 < 0	if a buyer's BD influences the price and demands a discount for lost lending opportunities on stocks with high specialness spreads. if a buyer demands a discount for failed delivery because he senses impending doom to the processing system, a major BD firm, or financial markets in general. As his account is debited on settlement, he worries that undelivered securities will negatively affect him.
b_2 > 0	if a seller demands a premium because a failed delivery turns a regular trade into an extended forward contract which benefits the buyer.

V. Data

Risk-Free Rate of Return Proxy

The compensation measures for the payment delay, $c_{i,t}$, are expected to be the risk-free rate of return for waiting for delivery of cash for securities, as discussed above. Following DeGennaro (1990), I use the daily effective Federal funds rate, which is easily accessible, as a proxy for the risk-free rate of return. Alternative proxies include the prime rate (used by Lakonishok and Levi (1982)), the broker's call rate, or the yield on T-bills. However, the Fed funds rate is better than the alternatives because it is more responsive to economic conditions. While some argue that the Fed funds rate is manipulated, all these measures of the risk-free rate are subject to the same criticism. I would prefer to use closing Fed funds rates to be in sync with the available equity data that uses closing prices. However, these data are not available. Therefore, I assume that the effective Fed funds rate is equal to the closing rate.

The Federal Reserve describes the daily effective Federal funds rate as "a weighted average of rates on brokered trades." The weighting is done by volume on trades arranged by major brokers, and the rates are "annualized using a 360-day year or bank interest." Rates are updated weekly on the Fed's website, but the Federal Reserve Bank of New York updates these values every day.[35]

I convert the annualized Fed funds rates obtained from the Fed's website to continuously compounded rates to correspond with the model.[36] The quoted rate is annualized using a 360-day year with the bank discount method. Hull (2006) converts an annual rate quoted with a compounding frequency of m times per year, R_m, to an annual continuously compounded rate, R_c, using the following equation.

$$R_c = m \ln\left(1 + \frac{R_m}{m}\right) \quad (28)$$

I perform this conversion, and then I divide by 365, or 366 in leap years, to obtain a daily continuously compounded rate for each day. For example, on June 7, 1995, the first day in the sample, the effective Fed funds rate is reported as 6.15%, compounded daily using a 360-day year. I convert this to the continuously compounded rate of 6.1495% (=360*ln(1+0.0615/360) and then divide by 365 days in the year for a daily continuously compounded rate of 0.01685%.

[35] See http://www.newyorkfed.org/markets/omo/dmm/fedfundsdata.cfm.
[36] Data were obtained from the Federal Reserve Selected Interest Rates, Release H.15 Federal funds (effective) – daily. Available at www.federalreserve.gov.

Return on the Market

For the observed return on U.S. equity securities, I use daily stock market index return data, consisting of both value-weighted and equal-weighted returns including distributed dividends, from CRSP during 2004 to 2009. The CRSP Data Descriptions Guide reports that daily returns for the equal- and value-weighted indices are calculated using closing price and share data. Securities must have data available for prices and shares outstanding on the current and previous trading day. American Depository Receipts (ADRs) are not included in the value-weighted index calculations, but they are included in the equal-weighted index. Index returns are calculated from a portfolio constructed on each trading day from all issues listed on the exchanges with value price data. Exchanges include the NYSE, Amex, and NASDAQ. Approximately 7,500 stocks, on average, were included in either daily index over the sample period from June 7, 1995 to December 31, 2009.

Value-weighted index returns are based on a value-weighted portfolio while equal-weighted index returns are based on an equal-weighted portfolio. For the value-weighted index, weighting depends on the total market value of each issue at the end of the last period, or trading day. This beginning total value, or market capitalization, is the price times the number of shares outstanding on the prior trading day. For the equal-weighted index, each issue receives the same weight in the portfolio.

CRSP reports daily index returns as the change in value of the portfolio over the daily holding period. Specifically, prices used to calculate returns are the last sale price or closing bid/ask average of the day. If a stock trades on multiple exchanges, the closing price is the price from the exchange that had the latest trade in the day. Automated trades and after hours trades are not recorded as the close price or as the average of the bid-ask spread, but they are recorded in trade volume statistics. CRSP reports the contract price, which is the price determined in the market, not the settlement price. The settlement price is used internally at NSCC to net trades and to determine the CCA.

Security prices reflect trading by both institutions and individuals. As discussed earlier, institutions hold more U.S. equities than individuals in value terms, and they may trade blocks of 10,000 shares or more since they have such large portfolios. Block trading on the NYSE suggests that institutional trades may be only a small percentage of total trades, averaging less than 20% of the dollar volume of all trades over this sample period and declining over time. CRSP reports returns using prices from either individual trades or institutional trades depending on which category of trader has the last trade of the day.[37] All trades reported to the clearing corporation are also reported to the market and thus available in the data source for the study.

[37] WRDS Support said, “CRSP uses close of the day market price to calculate returns (regardless of whether this price was set by institutions or individuals).”

Measure of Fails

From Model C above, the compensation measure for the risk of failed delivery is a premium or discount extracted by the seller or buyer and depends on the perceived probability of failed delivery. As the portion of outstanding fails to total volume increases in the market, the probability of failed delivery presumably increases for each market participant. Neither institutional nor individual buyers know who will deliver, or fail to deliver, shares when trades are processed. The identity of the opposing party is irrelevant. Rather, the proportion of fails in the market affects participants' expectation of the probability of failed delivery. Thus, I proxy for the likelihood of failed delivery with daily total failed shares to total market trade volume, as described below.

The SEC reports daily fails data collected from the NSCC's CNS system. The fails data are available daily on equity market settlement days from March 22, 2004 through December 31, 2009. Generally, settlement days are the same as equity market trade days, but there are a few exceptions. Data are missing on August 9, 2004, November 3, 2004, November 4, 2004, and December 26, 2006. Data are also not available on DTCC holidays that are different than equity market holidays, including all Columbus Day holidays on the second Monday in October and most Veterans Day holidays on November 11. If November 11 falls on a Sunday, no data are available on November 12; the official holiday is observed on the following Monday. If November 11 falls on a Saturday, all data around this date are available. For example, Veterans Day 2006 fell on Saturday, and no settlement holiday was observed around this time.[38]

The CNS system only processes broker-to-broker trades through the clearing corporation; it does not capture ex-clearing trades or institutional trades. In comparison to a bilateral settlement system, like an ex-clearing trade, netting in the CNS system drastically reduces the number of interfirm trades, so the CNS system processes fewer receives and delivers. The CNS system also rolls fails onto the next day's settlement as open positions. Since NSCC fills the oldest receive positions first, fails are outstanding for shorter periods of time than they would be under a bilateral settlement system.

As a result of both the type of trade processed and the means by which trades are processed, the CNS fails data provide a conservative proxy for the number of fails that occur in the equity market. Therefore, I expect a conservative measure of the risk of failed delivery because the smaller observable number of fails is divided by the total trade volume in the market as reported by CRSP. However, the impact on the independent variable of change in probability of failure may be small if the time series properties of the CNS system fails are similar to those of fails in ex-clearing or institutional trades. Unfortunately, the data are not available to include ex-clearing trades or institutional trades and to investigate the differences.

[38] I discuss how these missing data were handled in the results section.

As a proxy for the risk of failed delivery in equity markets, I use the total number of fails per day aggregated over all listed companies in the SEC data scaled by daily trade volume aggregated over all companies in the CRSP data. For each trade day, CRSP market index data include returns for all companies actively trading in the equity market, while the SEC fails data include a subset of those companies with outstanding fails.

I use two measures of the probability of failed delivery on the settlement day, T+3. First, the total number of failed shares on T divided by the total number of shares traded on T serves as the trader's best estimate of the probability of failed delivery on settlement at T+3. Second, the total number of failed shares on T+3 divided by the total number of shares traded on T+3 assumes that traders are able to estimate the probability of failure on the settlement date with certainty.

VI. Results

To estimate Model A and Model B, I use a sample of nearly 15 years of daily data from June 7, 1995 to December 31, 2009. There are 5,322 calendar days in this sample, and 3,670 total trading days. On average, there are 252 trading days every year. The year with the fewest trading days was 2001 because equity markets unexpectedly closed from Tuesday, September 11 through Friday, September 14, 2001 in the wake of the terrorist attacks on the World Trade Center. However, the DTCC continued to clear and settle trades from the preceding days. According to the 2001 DTCC Annual Report, "clearing and settlement took place each business day." In 1995, the sample captures over half, or 144 out of 252, of the trading days.

To estimate Model C, I use the available sample of nearly six years of daily fails data from March 22, 2004 to December 31, 2009. In 2004, the sample captures over three-quarters, or 198 out of 252, of the trading days. There are 2,111 calendar days in this sample, and 1,457 total trading days. While CRSP captures all 1,457 trade days, the SEC Reg SHO data does not include fails data for 15 trade days. Missing data occur on August 9, 2004, November 3, 2004, November 4, 2004, and December 26, 2006. Also, no fails exist for certain DTCC holidays that do not coincide with stock market holidays because the NSCC does not settle equity trades on these days. No fails data were available for Columbus Day in all six years on the second Monday of the month of October. Also, data were unavailable for Veterans Day in five of the six years. While Veterans Day always falls on November 11, it was observed on Monday, November 12 in 2007, but it was not observed in 2006 when the eleventh fell on a Saturday.[39] Table 8 shows trading and calendar days in both samples.

The impact of the 15 observations of missing Reg SHO data is that the sample size is reduced by 30 observations because the independent variable computed, the change in the probability of fail, is void for both the day of the missing value and the following day. Stata, the statistical package used to estimate the models, reports that missing data are allowed in maximum likelihood estimations of the ARCH family of estimators. The priming value, or the expected unconditional variance based on the current parameter estimates, is used as needed for the missing observations. Stata warns against using data with large portions that are missing. However, a small amount of missing data is tolerable asymptotically. I estimate models with 30 missing observations out of over 1,400 observations, meaning approximately 2% are missing.

Table 9 shows summary statistics of the daily return of the CRSP market portfolio indices over the full sample period, three subsamples of approximately equal length,

[39] Based on the different holiday schedules for equity trading markets and the main equity processing institution (DTCC), over the 15-year sample, I adjust the payment delay factor to reflect the extended settlement for trades that should have settled on Columbus or Veterans Day by an extra day, with the exception that if November 11 fell on a Saturday, I assumed it was not observed by DTCC.

Table 8. Number of trade days and calendar days used to estimate the models.

Trade Days by Year	Models A and B	Model C
1995	144	-
1996	254	-
1997	253	-
1998	252	-
1999	252	-
2000	252	-
2001	248	-
2002	252	-
2003	252	-
2004	252	198
2005	252	252
2006	251	251
2007	251	251
2008	253	253
2009	252	252
Total Trade Days	**3,670**	**1,457**
Total Calendar Days	**5,322**	**2,111**

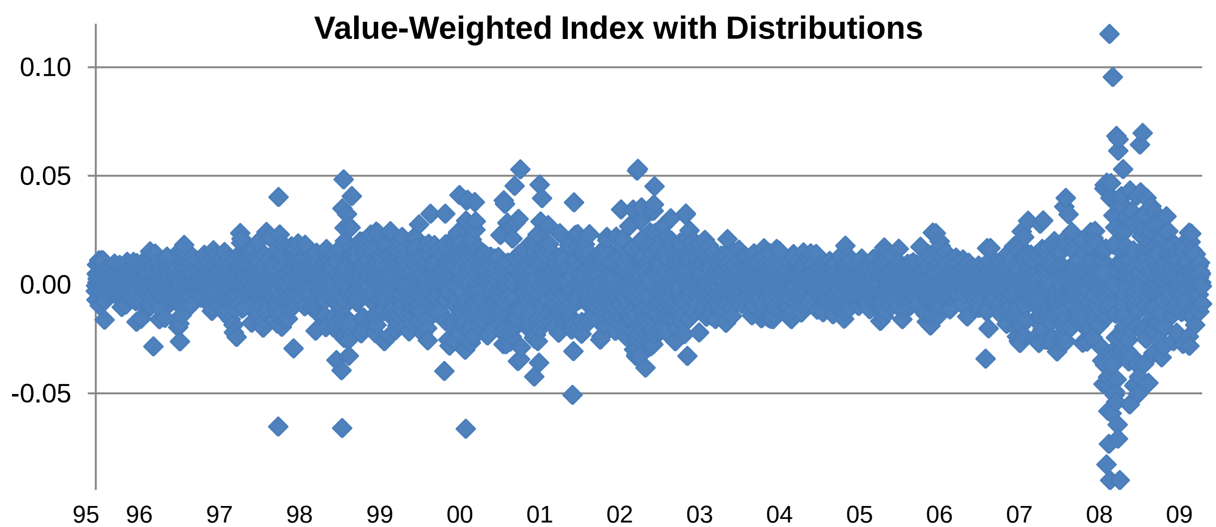
and the sample period covering the fails data.[40] In this study, I use the value-weighted index with dividends (VW) and the equal-weighted index with dividends (EW). Over the entire sample period, the average (median) daily return is 0.04% (0.09%) for VW and 0.08% (0.17%) for EW. The geometric mean daily return over the full sample period is 0.03% for VW and 0.08% for EW. By index, returns were highest in the early subperiod. The lowest mean and median return occur in the middle subperiod for VW and in the late subperiod for EW. Over the full sample, the standard deviation of returns is higher for VW at 1.28% than for EW at 1.08%. From early to middle to late subsamples for both indices, both the standard deviation and the range of observed returns increase. Note the extreme range of observed daily returns. The largest daily return for VW was 11.52% on October 13, 2008 while the smallest daily return for VW was -8.99% on October 15, 2008.

Figure 5 shows scatter plots of the daily return by index. The top chart shows the VW return against time while the bottom one shows the daily EW return. Figure 6 shows the average of daily returns for VW and EW for each year in the sample period.[41] As expected from the overall average daily return, the VW average is lower than the EW

[40] Additional summary statistics are available in Appendix A.3.
[41] Figure A.3.1 includes a comparison of the indices without dividends.

Table 9. Daily return (%) by index.

	Value-weighted Index with dividends	Equal-weighted Index with dividends
Payment Delay Full Sample (6/7/95 to 12/31/09) n = 3,670		
average	0.0373	0.0845
median	0.0886	0.1697
maximum	11.52	10.74
minimum	-8.993	-8.031
standard deviation	1.283	1.081
Early Subperiod (6/7/95 – 12/31/99) n = 1,155		
average	0.0949	0.1195
median	0.1396	0.2063
maximum	4.833	2.798
minimum	-6.595	-5.432
standard deviation	0.9634	0.6914
Middle Subperiod (1/3/00 – 12/31/04) n = 1,256		
average	0.0033	0.0922
median	0.0494	0.1551
maximum	5.316	4.838
minimum	-6.628	-6.353
standard deviation	1.281	0.9923
Late Subperiod (1/3/05 – 12/31/09) n = 1,259		
average	0.0183	0.0446
median	0.0950	0.1242
maximum	11.52	10.74
minimum	-8.993	-8.031
standard deviation	1.519	1.409
Failed Delivery Sample (3/22/04 – 12/31/09) n = 1,457		
average	0.0238	0.0492
median	0.0925	0.1331
maximum	11.52	10.74
minimum	-8.993	-8.031
standard deviation	1.435	1.335



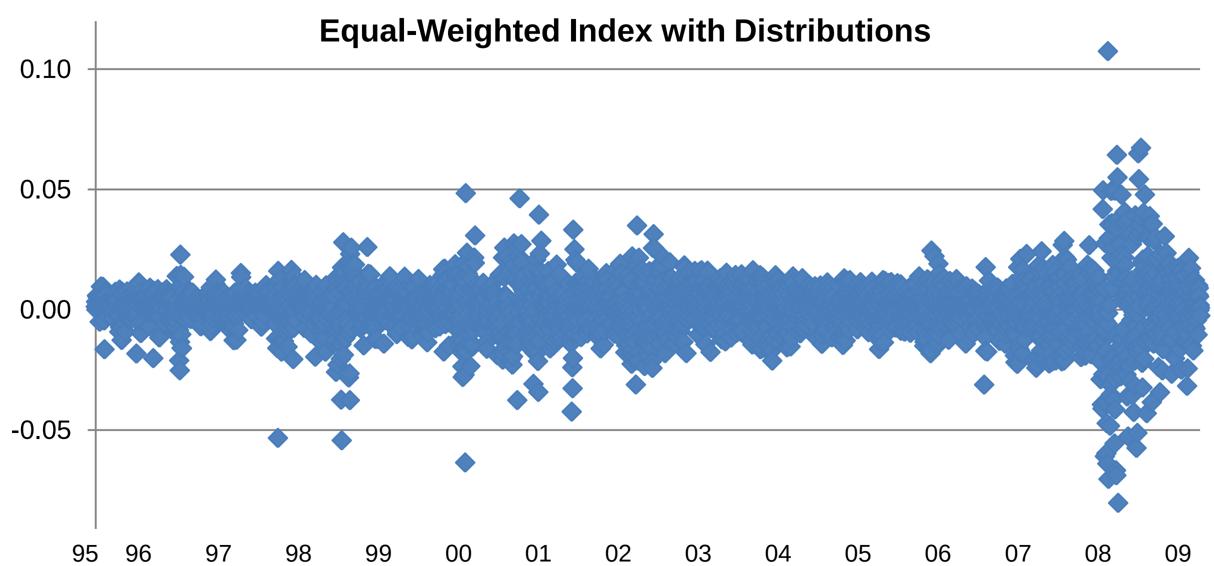


Figure 5. Scatter plots of daily returns by index over the sample period.

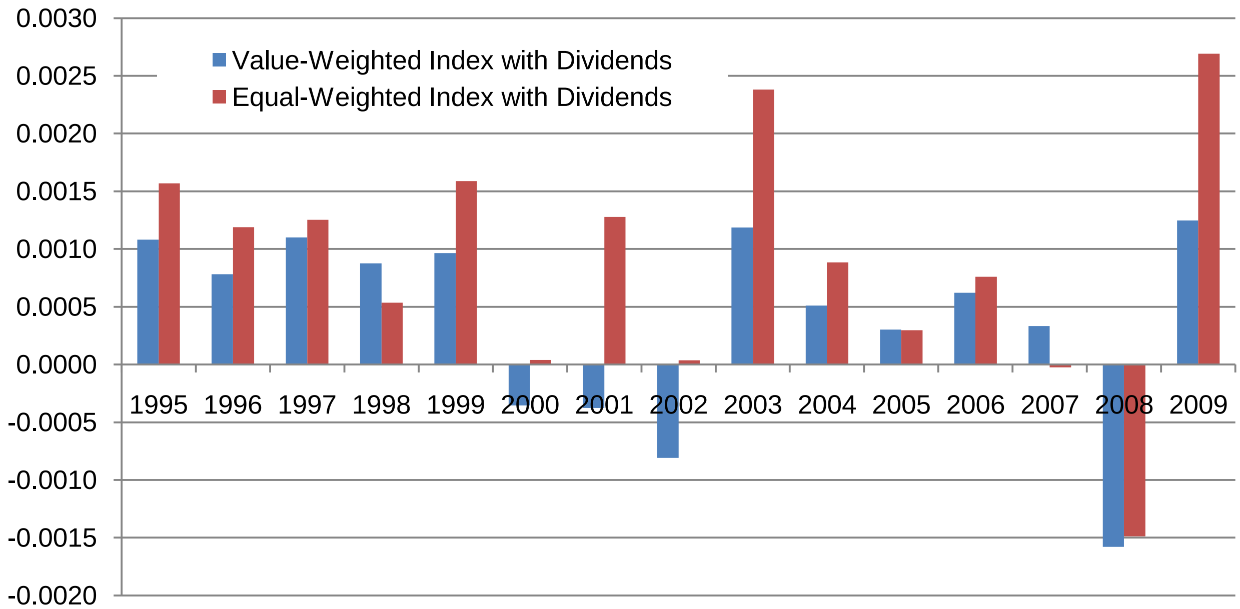


Figure 6. Average daily returns by year and index.

average in most, 12 out of 15, years. VW had a higher average daily return in 1998, 2005, and 2007. Also, EW had a positive daily average for more years than VW. VW was negative in 2000, 2001, 2002, and 2008 while EW was negative in 2007 and 2008.

Table 10 shows the summary statistics for the annualized daily effective Fed funds rate. Over the 5,322 calendar days in the sample period, the average (median) annualized daily effective Fed funds rate was 3.70% (4.66%). The standard deviation was 2.01%. The largest rate, 7.80%, occurred on July 1, 1996. The smallest rate, 0.05%, occurred on December 31, 2009. Figure 7 graphs this rate for the sample period.

Table 10. Annual effective Fed funds rate (%) over the entire sample period.

Annual Effective Fed Funds Rate	
average	3.70%
median	4.66%
mode	5.25%
maximum	7.80%
minimum	0.05%
standard deviation	2.01%
observations	5,322

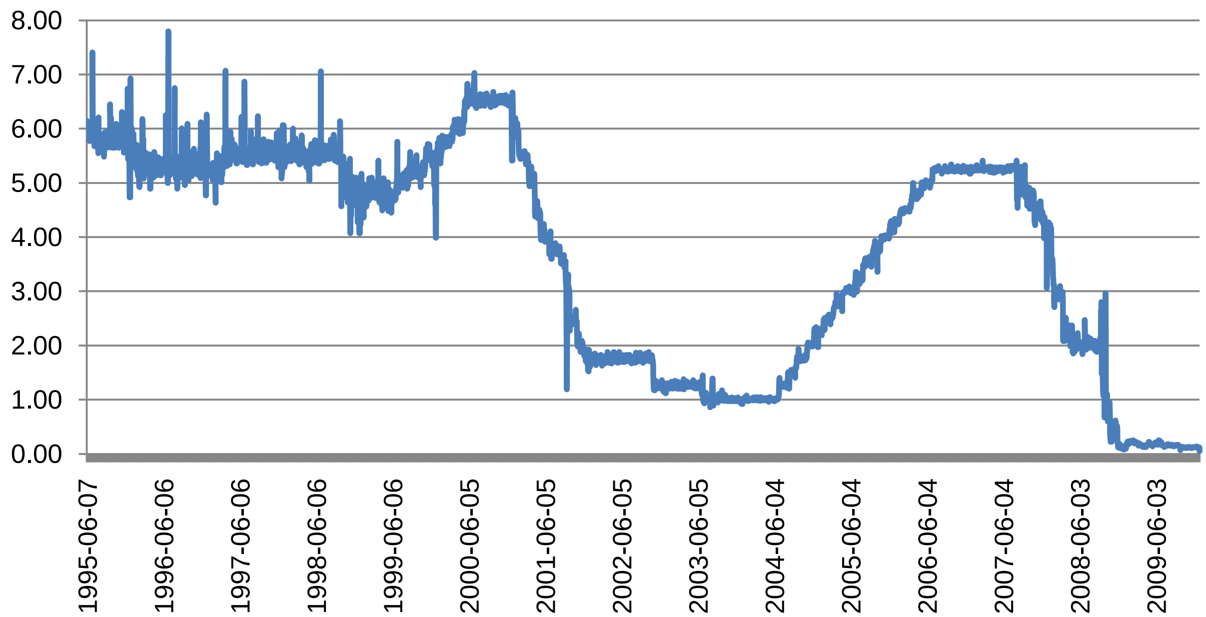


Figure 7. Annualized daily effective Fed funds rate (%).

Next, I model the time series properties of the VW and EW indices. I expected the error term to follow a first-order moving average process. Nonsynchronous trading of securities caused daily portfolio returns to be autocorrelated, predominantly at the first lag, in Scholes and Williams (1977). Gibbons and Hess (1981) reported autocorrelations at the first lag of around 0.2 for the S&P 500 and VW index and approximately 0.4 for the EW index, using data from 1962 to 1978. DeGennaro (1990) found that the error term followed a first-order moving average process, and the lagged error term had a coefficient of 0.259 over 1970 to 1982. I confirmed that the first-order moving average process fits the VW index quite well over the time period used in DeGennaro (1990), from 1970-1982. Over the sample period for this study, I expected to find a coefficient smaller in magnitude, due to less thin trading, but close to these observations.

However, neither the VW or the EW index can be adequately described by a first-order moving average over this study's sample period. I examined correlograms of the autocorrelation and partial autocorrelation function for each index over the sample period. They do not support a typical pattern shown by moving averages, as illustrated in Enders (2004). Ljung-Box Q statistics show that the residuals remain significantly different from zero when the indices are fit with a MA(1) model.

Furthermore, attempts to fit the data with moving average or autoregressive models of varying lag lengths do not remove significant autocorrelations in the residuals. These types of models do not capture the true data-generating process. In prior periods, the VW and EW indices followed a MA(1) model due to either thin trading in some securities in the index, the speed that market participants processed information, or day of the week effects. It is likely that there has been a decline in these characteristics over time.

GARCH models allow the volatility of a time series to fluctuate over time, and periods of high and low volatility can be clustered in time. Engle (1982) originally proposed the ARCH model, and Bollerslev (1986) developed a more general GARCH model. Various specifications are used in studies in the financial literature, and GARCH(1,1) is popular due to its parsimony. Bollerslev, Chou, and Kroner (1992) provide a survey of this literature, documenting numerous studies that model conditional variance using financial data. I find that the features of the data are best fit with a GARCH(1,1) model. The model fits the data using conditional maximum likelihood. The conditional mean and the conditional variance are shown in equations (29) and (30), respectively.

$$R_t = XB + e_t \tag{29}$$

$$h_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 h_{t-1}^2 \tag{30}$$

$$e_t \sim N(0, h_t^2)$$

The ARCH parameter (α_1), GARCH parameter (α_2), and constant (α_0) in the conditional variance equation are estimated when the model is fit to the data. The sum of the ARCH and GARCH parameters indicates the rate of decay of the autoregressive feature of the squared error. Also, larger values of the parameters result in larger conditional variances. Larger values of the ARCH parameter indicate greater responsiveness of the conditional variance to news.

Engle (1982) recommends a Lagrange multiplier test for detecting ARCH disturbances, which requires regressing the squared residuals from OLS on a constant and the first several lagged values of the squared residuals. The number of squared residuals is multiplied by the coefficient of determination; this test statistic converges to a Chi-squared distribution with degrees of freedom equal to the number of lags used in the regression. I performed this test for varying lag lengths and rejected the null hypothesis that there are no ARCH errors in all cases examined. In other words, the conditional variance is not constant.

Next, to construct the probability of failure variable, I match the fails data to the CRSP data, aggregate fails, divide by aggregated volume, and difference the ratio. Details of this process are as follow. First, I check whether each observation in the fails data is also available in the CRSP data. I matched the fails data, which contains a combination of unlisted penny stocks, ETFs, and NYSE and NASDAQ stocks, to the CRSP data.

Before matching, I exclude certificates, shares of beneficial interest, and units so that the resulting sample includes ordinary common shares as characterized by CRSP. Boni (2006), who investigates fails in equities, uses this procedure, and it is common in other studies using equity returns [see Loughran (1993) and Chordia et al. (2000)]. To find the daily total CRSP volume for the value-weighted index, I also exclude ADRs. I aggregate volume over CRSP's share codes 10, 11, 12, 14, 15, and 18. For the daily total CRSP volume for the equal-weighted index, I aggregate volume over share codes for ordinary common shares and ADRs. These include share codes of 10, 11, 12, 14, 15, 18, 30, and 31.

The fails data includes the following fields: date, cusip, ticker symbol, company description or name, number of failed shares, and price per share. The acronym cusip, for Committee of Uniform Securities Identification Procedures, is a unique identifier for the majority of U.S. securities used to aid clearing and settlement according to the SEC. A cusip is made up of nine letters or numbers. All nine digits are reported in the Reg SHO data, but CRSP only reports an eight-digit cusip. According to CRSP,

> "The first six characters uniquely identify the issuer and have been assigned to issuers in approximate alphabetical sequence. The seventh and eighth characters identify the issue. The ninth character is used as a check digit and is not stored in the CRSP US Stock Databases." [42]

Therefore, I manually matched several companies between the two databases until I was convinced that the CRSP cusip was simply the Reg SHO cusip without the final digit. Then, I merged the two databases, matching on cusip and the date.

The daily fails in a particular stock reports the total number of fails outstanding. The data include fails from the prior settlement day minus any of those fails that are resolved on the current settlement day plus any new fails on the current settlement day. Therefore, the value reflects some combination of new and existing fails, and there is no way to determine the length of time that the fails have been outstanding.

The Reg SHO data first reported prices in April of 2007. Although the price per share data were missing for many observations during the sample period, I did not need this data to estimate any model. Starting in July of 2009, the fails data included fails in a stock of less than 10,000 shares. Prior to this date, fails of less than this were not reported in the data, so the calculated probability of failure may be smaller than the true probability of failure.

The process of matching allowed me to remove penny stocks from the data as well as any other fails observations that did not appear in CRSP. Then, I aggregated fails over

[42] http://www.crsp.com/documentation/kb/data/stock/stk-0006.html.

all companies that were present in the CRSP database on that day; the result measures daily total fails. I did this both with and without ADRs.

I scale the daily total fails without ADRs by the daily total CRSP volume without ADRs. I use the resulting ratio, or the probability of fails on a particular day excluding ADRs, to estimate coefficients in the model with the value-weighted index, which excludes ADRs. I scale the daily total fails with ADRs by the daily total CRSP volume with ADRs. The resulting ratio, or the probability of fails on a particular day including ADRs, is used to estimate coefficients using the equal-weighted index, which includes ADRs.

Table 11 reports the descriptive statistics for the SEC Reg SHO data, the CRSP total volume data, and the computed probability of failure variable. The average fails for the VW index are 119 million shares per day while total daily volume is about 5 billion shares per day. Total fails range from 14.8 to 419 million shares per day for the VW index; total volume ranges from 1.29 to 14.1 billion shares per day. While the daily probability of failure ranges from 0.19% to 10.7%, on average, it is 2.62% over the sample period. The probability of failure varies with time; it is highest in 2004 and lowest in 2009, although the decline is not monotonic.

The drastic drop in the probability of failure observed in 2009 to about half a percent is due to an additional regulation written by the SEC as an amendment to Reg SHO [Release No. 34-60388; File No. S7-30-08]. Originally, temporary Rule 204T was adopted in October 2008, and it was followed by the permanent adoption of Rule 204 on July 31, 2009. The rule requires clearing firms with net failed deliveries to close out the position on the next trading day after the fail occurs. This can be accomplished by either borrowing shares for delivery (as equity loans settle on T rather than T+3) or buying shares (which would net at midnight on T+1, closing out the open position). If the clearing firm does not deliver, it violates the rule and may not short sell in the security for its own account or for anyone else's account until the fail is resolved.

Figure 8 shows scatter plots of total fails, total volume, and the probability of failure for the value-weighted index. Scatter plots of these variables for the equal-weighted index are similar.

Table A.3.3. in the appendix shows sample statistics for the differential compensation measures used in Models B and C. These include the differential compensation for payment delay variable, ΔF_t, based on both observable and actual rates and the differential compensation for the probability of failed delivery variable, $\Delta\,\mathrm{Pr}(\mathrm{Fail}_t)$, using the difference in fails both on T minus T-1 and on T+3 minus T+2.

Table 11. Descriptive statistics for fails, volume, and probability of failure.

The count is the number of daily observations of each variable. All other statistics are daily values. Fails and volume data are reported in number of shares. Moments of the distributions are computed such that a normal distribution would have a skewness of zero and a kurtosis of three.

Panel A. Entire sample from 3/22/04 – 12/31/09.

	Total Fails		Total Volume		Probability of Failure	
	VW	EW	VW	EW	VW	EW
count	1,442	1,442	1457	1457	1,442	1,442
average	119 M	127 M	5.06 B	5.32 B	2.62%	2.67%
median	101 M	109 M	4.52 B	4.74 B	2.69%	2.65%
maximum	419 M	437 M	14.1 B	14.9 B	10.7%	10.8%
minimum	14.8 M	18.7 M	1.29 B	1.36 B	0.19%	0.21%
standard deviation	71.4 M	74.3 M	1.84 B	1.95 B	1.49%	1.50%
skewness	1.18	1.13	1.05	1.02	0.40	0.38
kurtosis	4.82	4.65	3.99	3.88	3.54	3.51

Panel B. Averages by year.

	2004	2005	2006	2007	2008	2009
VW						
total fails	144 M	98 M	87 M	147 M	206 M	36 M
total volume	3.36 B	3.60 B	4.16 B	4.96 B	6.65 B	7.27 B
fails/volume	4.42%	2.76%	2.13%	3.04%	3.27%	0.52%
EW						
total fails	154 M	105 M	94 M	157 M	217 M	39 M
total volume	3.48 B	3.74 B	4.35 B	5.23 B	7.04 B	7.65 B
fails/volume	4.56%	2.85%	2.20%	3.07%	3.26%	0.54%

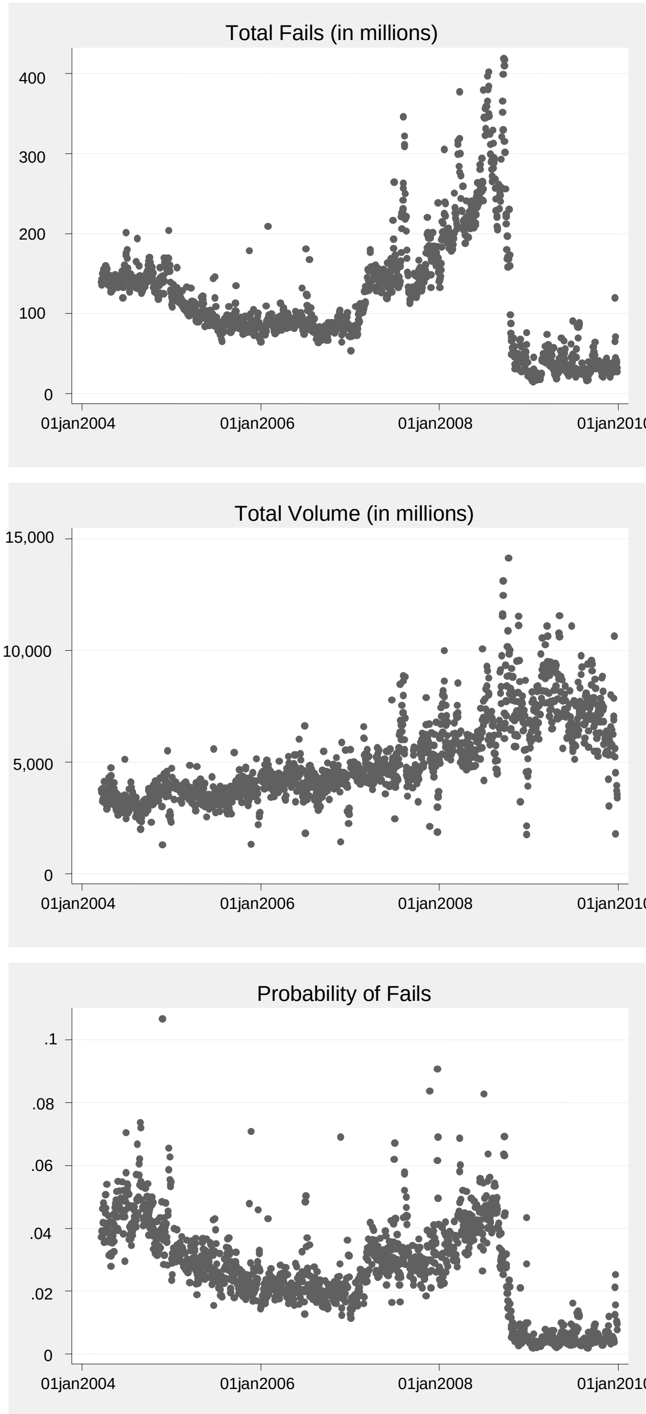


Figure 8. Scatter plots of total fails, total volume, and probability of fails for the value-weighted index.

Estimation of Model A

Model A assumes immediate delivery and settlement. I estimate equation (9), $R_t = b_0 * n_t + e_t$, to test the calendar time versus trading day hypothesis. The results of the estimation are shown in Table 12. In the first column for each index, the ordinary least squares (OLS) regression estimates robust standard errors. For the entire sample, I fail to reject the null hypothesis that the b_0 coefficient is zero for the value-weighted index. There is weak evidence (significance at the 10% level) to support the rejection that b_0 is zero for the equally-weighted indices. I split the sample into thirds to create approximate five-year subsamples. There is strong support that the b_0 coefficient is not zero for both indices at the 1% level in the earliest subsample. In the other subsamples, the b_0 coefficient appears to be indifferent from zero; the only exception is for the equally-weighted index in the late sample.

In the second column for each index, the regression models the error term using GARCH(1,1). Using this model, I reject the null hypothesis that b_0 is zero for the full sample in both indices at the 1% level. The null can also be rejected for all subsamples at the 5% level except for the middle sample for the VW index. Since the calendar day hypothesis holds for both indices over the entire sample period using GARCH(1,1), I retain the days in the holding period as an explanatory variable in the estimations of Model B and C below.

In the GARCH(1,1) model of the conditional variance, $h_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 h_{t-1}^2$, the α_1 and α_2 estimates sum to less than one in all cases. For example, the VW estimation over the entire sample shows that these coefficients sum to 0.992 (=0.088+0.904). For the EW estimation over the entire sample, these coefficients sum to 0.980 (=0.135+0.845). The coefficients must be less than one in aggregate to satisfy the assumptions of the model. The model assumes a constant unconditional variance with a long-run average of $\alpha_0/(1-\alpha_1-\alpha_2)$. If α_1 and α_2 sum to more than one, the result would imply a negative unconditional variance, which is nonsensical. Furthermore, the conditional variance would explode. Therefore, I check that predicted values of the conditional variance are generated by a stationary process using the Phillips-Perron unit root test. I reject the null hypothesis that the conditional variance contains a unit root.

I present z-statistics for all estimations of GARCH models in this study. Stata, the statistical package used to estimate the models, reports “semi-robust standard errors” that are used to compute the z-statistics. Estimates are stated to be “robust or quasi-maximum likelihood estimates of variance” that are derived using the familiar White (1980, 1982) estimator. The software package boasts that its full method is better than others that “set some terms to their expectations of zero, which saves them from calculating second derivatives of the log-likelihood function.”

Table 12. Estimation of Model A.

Estimation of $R_t = b_0 * n_t + e_t$ where R_t is the index return for each trading day and n_t is the number of days in the holding period. All estimations are performed without a constant. The full sample covers 6/7/95-12/31/09 with 3,670 observations. The early subperiod covers 6/7/95-12/31/99 with 1,155 observations. The middle subperiod covers 1/3/00-12/31/04 with 1,256 observations. The late subperiod covers 1/3/05-12/31/09 with 1,259 observations. For OLS, estimates of b_0 are reported, and t statistics are shown in parentheses. For GARCH(1,1), the error term is modeled as $h_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 h_{t-1}^2$; estimates of b_0, α_0, α_1, and α_2 are reported, and z statistics are shown in parentheses.

	VW OLS	VW GARCH (1,1)	EW OLS	EW GARCH (1,1)
Full Sample				
b_0	1.1x10^{-4} (0.76)	3.4x10^{-4}* (3.79)	2.3x10^{-4}*** (1.95)	4.9x10^{-4}* (6.48)
α_0		1x10^{-6}* (2.88)		2x10^{-6}* (3.83)
α_1		0.088* (6.75)		0.135* (6.98)
α_2		0.904* (70.75)		0.845* (44.38)
Early Sample				
b_0	5.1x10^{-4}* (2.74)	4.9x10^{-4}* (3.36)	4.3x10^{-4}* (3.10)	6.2x10^{-4}* (5.79)
α_0		2x10^{-6} (1.58)		4x10^{-6}* (2.87)
α_1		0.109** (2.45)		0.240* (3.46)
α_2		0.877* (19.36)		0.680* (9.47)
Middle Sample				
b_0	-1.0x10^{-4} (-0.43)	2.4x10^{-4} (1.3)	2.7x10^{-4} (1.42)	5.9x10^{-4}* (3.68)
α_0		1x10^{-6}*** (1.67)		4x10^{-6}* (3.17)
α_1		0.086* (4.36)		0.145* (5.38)
α_2		0.907* (44.77)		0.811* (25.62)
Late Sample				
b_0	-0.53x10^{-4} (-0.19)	2.9x10^{-4}** (2.13)	0.22x10^{-4} (0.08)	2.6x10^{-4}** (2.01)
α_0		1x10^{-6}** (2.03)		1x10^{-6}** (2.30)
α_1		0.084* (6.73)		0.093* (6.84)
α_2		0.906* (72.10)		0.895* (66.53)

* significant at the 1% level
** significant at the 5% level
*** significant at the 10% level

Estimation of Model B

Model B assumes a three business day payment delay. In equation (17), $R_t = b_0 + b_1 \Delta F_t + e_t$, I replace the constant with the number of days in the holding period based on evidence that supports the calendar day hypothesis in the estimation of Model A above. Using a GARCH(1,1) model, I estimate $R_t = b_0 * n_t + b_1 \Delta F_t + e_t$, which reflects the calendar day hypothesis, to test whether the payment delay that results from settlement on T+3 is incorporated into equity returns. Results are shown in Table 13. Therein, the differential compensation for payment delays reflects the process described by Table 4, which assumes the payment delay is a function of rates that are observable to the investor on the trade date.

In the first column, for the entire sample, the null hypothesis that the b_0 and the b_1 coefficients are zero (individually or jointly) is rejected at the 1% level for both the value-weighted and equal-weighted indices. Again, I split the sample into three subsamples to create approximate five-year subsamples. Except for the value-weighted index in the middle subsample, there is strong support that the b_0 coefficient is not zero for both indices at the 1% level in all subsamples. However, the b_0 coefficient is larger than the actual arithmetic or geometric average actual return, shown in Appendix A.3, in almost every sample; this holds for a variety of specifications of the model performed as robustness checks and discussed below. Also, the b_1 coefficient appears to be different than zero at the 5% level. The lack of significance of all of the estimated coefficients in the mean equation for the value-weighted index in the middle subsample may reflect the unique characteristics of the index return during this period. The observed daily average return was extremely low at 0.33 basis points.

I expected to reject the null hypothesis that b_1 is equal to zero because I expected the payment delay from settlement to be incorporated into equity returns. Furthermore, I expected b_1 to be approximately equal to one, which would suggest that the buyer compensates the seller at the risk-free rate of return. Finally, over the full sample, I expected b_1 to be less than 1.66 using the value-weighted index, which is the value that DeGennaro (1990) obtained over the period from 1970-1982. A value smaller than 1.66 would reflect that the current settlement system may be safer than the preceding settlement system due to the role of the clearing corporation as central counterparty.

While the null hypothesis that b_1 is equal to zero can be rejected for nearly every case examined, the value of the point estimate for b_1 is much larger than expected. Over the entire sample, the results using the value-weighted index suggest that the buyer compensates the seller at nearly three times the risk-free rate over the settlement period (b_1= 2.78). Compensation is even greater using the equal-weighted index. These results imply that buyers compensate sellers at nearly five times the risk-free rate over the settlement period (b_1= 4.56).

Table 13. Estimation of Model B based on observable rates.

Maximum likelihood estimation of $R_t = b_0 * n_t + b_1 \Delta F_t + e_t$ where R_t is the daily return on the index for each trading day and n_t is the number of days in the holding period. ΔF_t is the differential compensation for payment delays from Table 4, using rates observable to the investor on the day of the trade. The estimation is performed without a constant. The error term is modeled as a GARCH(1,1) process such that $h_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 h_{t-1}^2$. Estimates of b_0, b_1, α_0, α_1, and α_2 are reported. z-statistics are shown in parentheses.

	Full Sample 6/7/95-12/31/09 n=3,669	**Early Sample** 6/7/95-12/31/99 n=1,154	**Middle Sample** 1/3/00-12/31/04 n=1,256	**Late Sample** 1/3/05-12/31/09 n=1,259
VW index				
b_0	4.4×10^{-4}* (4.70)	6.6×10^{-4}* (4.35)	2.6×10^{-4} (1.36)	4.2×10^{-4}* (2.82)
b_1	2.78* (2.96)	3.21* (2.70)	1.07 (0.36)	3.89** (2.43)
α_0	1×10^{-6}* (2.83)	2×10^{-6}*** (1.66)	1×10^{-6}*** (1.65)	1×10^{-6}** (2.00)
α_1	0.088* (6.86)	0.112* (2.57)	0.086* (4.38)	0.084* (6.62)
α_2	0.904* (71.53)	0.876* (20.22)	0.907* (45.01)	0.906* (70.04)
EW index				
b_0	6.7×10^{-4}* (8.32)	9.3×10^{-4}* (7.89)	7.0×10^{-4}* (4.17)	4.2×10^{-4}* (2.90)
b_1	4.56* (6.70)	5.10* (6.20)	4.29** (2.09)	4.67* (3.21)
α_0	2×10^{-6}* (3.83)	4×10^{-6}* (3.16)	4×10^{-6}* (3.20)	1×10^{-6}** (2.27)
α_1	0.138* (7.15)	0.278* (3.73)	0.145* (5.47)	0.093* (6.77)
α_2	0.842* (44.78)	0.646* (9.72)	0.812* (26.30)	0.893* (64.23)

* significant at the 1% level
** significant at the 5% level
*** significant at the 10% level

The fact that the estimates of b_1 are over one and a half times greater using the equal-weighted index as opposed to the value-weighted index suggests that CRSP may be capturing different types of traders on different days. The equal-weighted index weights small-capitalization stocks more heavily than the value-weighted index. If institutions are more likely to trade in small, more thinly traded stocks, then the equal-weighted index is more likely to pick up institutional trades as the closing trade of the day. In other words, CRSP may be identifying the marginal trader in the equal-weighted index is an institution. Perhaps the larger compensation for payment delay observed with the equal-weighted index reflects different prices for institutions versus individuals.

The indices probably pick up a mix in terms of types of traders. Some days, the close price will reflect individual traders in a particular stock, and other days, the closing price will reflect institutional traders in a particular stock. Both types of traders likely have different pricing for delays. The value-weighted index may have more variation in terms of type of trader since it weights large-capitalization stocks more heavily. This may bias the estimates of the b_1 coefficient to insignificance because of larger standard errors. The equal-weighted index may reflect institutions more frequently, for the reason given relating to thin trading, so it may give a more precise estimate. This is reflected in the lower standard errors on the b_1 coefficients for the equal-weighted index. Furthermore, this may suggest that the compensation for payment delay for individuals is in fact close to the risk-free rate, although this cannot be determined explicitly. If the equal-weighted estimates are a true measure for institutions, and the value-weighted estimates are a weighted average of individuals and institutions, then the individual compensation rate must be lower than the point estimates shown using the value-weighted index.

I expect the results to be similar using the differential compensation for payment delays outlined in Table 5 using the daily rates for each day in a particular settlement period, and they are. The results of this estimation are shown in Table 14. Once more, the null hypothesis that the b_0 and the b_1 coefficients are zero (individually or jointly) is rejected at the 1% level for both the value-weighted and equal-weighted indices over the full sample. Except for the value-weighted index in the middle subsample, there is strong support that both the b_0 coefficient and the b_1 coefficient are different than zero.

In comparison to Table 13, the point estimates for b_1 are slightly larger in Table 14. Over the entire sample, the results using the value-weighted index suggest that the buyer compensates the seller at three times the risk-free rate over the settlement period (b_1= 3.00). Using the equal-weighted index, these results imply that buyers compensate sellers at nearly five times the risk-free rate over the settlement period (b_1= 4.75).

Table 14. Estimation of Model B based on actual rates.

Maximum likelihood estimation of $R_t = b_0 * n_t + b_1 \Delta F_t + e_t$ where R_t is the daily return on the index for each trading day and n_t is the number of days in the holding period. ΔF_t is the differential compensation for payment delays from Table 5, using rates over the actual settlement period. The estimation is performed without a constant. The error term is modeled as a GARCH(1,1) process such that $h_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 h_{t-1}^2$. Estimates of b_0, b_1, α_0, α_1, and α_2 are reported. z-statistics are shown in parentheses.

	Full Sample 6/7/95-12/31/09 n=3,669	**Early Sample** 6/7/95-12/31/99 n=1,154	**Middle Sample** 1/3/00-12/31/04 n=1,256	**Late Sample** 1/3/05-12/31/09 n=1,259
<u>VW index</u>				
$\boldsymbol{b_0}$	4.5×10^{-4}* (4.79)	6.9×10^{-4}* (4.51)	2.6×10^{-4} (1.35)	4.3×10^{-4}* (2.85)
$\boldsymbol{b_1}$	3.00* (3.09)	3.72* (2.94)	0.90 (0.30)	3.95** (2.49)
$\boldsymbol{\alpha_0}$	1×10^{-6}* (2.82)	2×10^{-6}*** (1.67)	1×10^{-6}*** (1.65)	1×10^{-6}** (2.00)
$\boldsymbol{\alpha_1}$	0.087* (6.88)	0.112* (2.59)	0.086* (4.38)	0.084* (6.63)
$\boldsymbol{\alpha_2}$	0.905* (71.76)	0.875* (20.27)	0.907* (44.99)	0.906* (70.11)
<u>EW index</u>				
$\boldsymbol{b_0}$	6.9×10^{-4}* (8.42)	9.6×10^{-4}* (7.99)	7.0×10^{-4}* (4.19)	4.2×10^{-4}* (2.92)
$\boldsymbol{b_1}$	4.75* (6.89)	5.46* (6.55)	4.25** (2.10)	4.69* (3.25)
$\boldsymbol{\alpha_0}$	2×10^{-6}* (3.83)	4×10^{-6}* (3.13)	4×10^{-6}* (3.20)	1×10^{-6}* (2.27)
$\boldsymbol{\alpha_1}$	0.138* (7.17)	0.277* (3.69)	0.145* (5.48)	0.093* (6.79)
$\boldsymbol{\alpha_2}$	0.842* (44.99)	0.645* (9.41)	0.813* (26.39)	0.893* (64.30)

* significant at the 1% level
** significant at the 5% level
*** significant at the 10% level

See Appendix A.4 for robustness checks of Model B. First, I estimate the original equation (17), $R_t = b_0 + b_1 \Delta F_t + e_t$, with the constant rather than the number of days in the holding period, which follows the trade day hypothesis. Results for the observed rates and actual rates are similar.

Results using observable rates are shown in Table A.4.1. In the first column, for the entire sample, I fail to reject the null hypothesis that the b_1 coefficient is zero for the value-weighted index. However, the b_0 constant is different from zero. This outcome is similar to that observed across the three subsamples. Alternatively, the null hypothesis that the b_0 and the b_1 coefficients are zero is rejected for the equal-weighted index for the full sample as well as for the early and later subsamples. In comparison to Table 13, the point estimates for b_1 are smaller in Table A.4.1. While insignificant, the estimates are close to one, suggesting the payment delay may be compensated at the risk-free rate, using the value-weighted index. Using the equal-weighted index, the estimate is significant and close to two, suggesting the settlement period dictates twice the risk-free rate.

Results using actual rates are shown in Table A.4.2. In comparison to Table 14, the point estimates for b_1 using actual rates and the trade day hypothesis are much smaller. The results using the value-weighted index are insignificant at conventional levels for all periods examined. Nevertheless, the point estimate of the coefficient for the payment delay over the entire sample period suggests that buyers compensate sellers at approximately the risk-free rate over the settlement period (b_1= 1.32 compared with b_1= 3.00 under the calendar day hypothesis). Using the equal-weighted index, the coefficient on the payment delay factor is significant in all but the middle subsample. Over the entire sample period, the results imply that buyers compensate sellers at twice the risk-free rate over the settlement period (b_1= 2.18 compared with b_1= 4.75 under the calendar day hypothesis).

Second, in Table A.4.3, I estimate the model, $R_t = b_0 + b_1(n_t - 1) + b_2 \Delta F_t + e_t$, based on actual rates over the settlement period corresponding to Table 5. This model allows the return to vary by calendar day versus trade day during the holding period. Therefore, b_0 captures the average return for a trade day while b_1 signifies the average return for each non-trade day (weekend day or holiday) in the holding period. Over the entire sample period (and for each subperiod), approximately 78% of all observations have a holding period of one day. About 18% of observations have a holding period of three days as a result of a normal weekend. The remaining 4% are the result of holidays, and the holding period is generally either two or four days.

Using the value-weighted index, although the constant is significant individually (though too big to be realistic when compared to the geometric return over the sample period), nothing is significant jointly for the full, early, or middle sample. In the late sample, there is joint significance; both the b_1 and b_2 coefficients are significant and quite large. In comparison to Table 14, where the payment delay factor is about four times the risk-free rate (b_1=3.95), here the payment delay factor implies compensation from buyers to sellers at over five times the risk-free rate over the settlement period (b_2=5.31).

Using the equal-weighted index, the constant is significant and equal to 0.15% average daily return over the full sample period. While this is close to the median daily return over that sample period, it is bigger than the average daily return. The non-trade days in the holding period are also significant at the 5% level, and the coefficient is negative (b_1= -0.04%). The payment delay factor is less than one (b_2= 0.65) but insignificant. For the three subsamples, the results differ based on the time period over which they are estimated. In the early subsample, the payment delay factor is insignificant and negative. Jointly, nothing is significant in the middle sample. In the late sample, only the payment delay factor is significant in the model of the mean. The payment delay factor here (b_2=4.86) is similar to that found in Table 14 (b_1= 4.69).

Overall, the model allowing trade days and non-trade days in the holding period to have different returns does not provide jointly significant coefficients in many of the studied periods, especially for the value-weighted index. In the late subperiod for both indices, it yields similar results to those found with the model estimated in Table 14.

Third, in Table A.4.4, I estimate $R_t = b_0 n_t + b_1 \Delta F_t + b_2 h_t^2 + e_t$, a GARCH-in-mean (GIM) model based on actual rates and the calendar day hypothesis. This type of model was proposed by Engle, Lilien, and Robins (1987). The conditional variance term is included in the mean equation, representing a tradeoff between risk and return.

For the full sample, the conditional variance term in the mean equation is significant in the model at conventional levels. Using the value-weighted index, the new coefficient has a value of approximately three (b_2=3.27), and the coefficient on the payment delay factor drops slightly (from b_1=3.00 to b_1=2.43). Using the equal-weighted index, the new coefficient is even larger (b_2=6.60); again, the coefficient on the payment delay factor drops (from b_1=4.75 to b_1=3.98). These results imply that equity returns are higher when conditional variance is higher. Although the payment delay factor declines when the GIM model is estimated, it is still larger than one, implying that compensation over the settlement period is greater than the risk-free rate of return.

For the three subsamples, the GIM results are less consistent. In the estimation of the mean equation using the value-weighted index, only the conditional variance term is significant in the early sample. Nothing is significant in the middle sample (individually or jointly), and all but the conditional variance term is significant in the late sample. The coefficients on b_0, b_1, α_0, α_1, and α_2 are nearly identical for the late sample in the GIM model and the comparable model without the conditional variance term in the mean equation shown in Table 14 (e.g., b_1=3.83 with GIM compared to b_1=3.95 in Table 14). For the equal-weighted index, all coefficients in the mean equation are significant in the early sample; only the conditional variance is significant in the middle sample, and all but the conditional variance is significant in the late sample.

Finally, in Table A.4.5, I estimate this equation to test the equality of the coefficients: $R_t = b_0 n_t Early + b_1 n_t Mid + b_2 n_t Late + b_3 \Delta F_t Early + b_4 \Delta F_t Mid + b_5 \Delta F_t Late + e_t$. The implications of the results of this estimation for observed rates and actual rates are the same. Therefore, the table reports the differential compensation for payment delays from Table 5, using actual rates over the settlement period. Early is an indicator variable equal to one if the date is from 6/7/95 to 12/31/99. Mid is an indicator variable equal to one if the date is from 1/3/00 to 12/31/04. Late is an indicator variable equal to one if the date is from 1/3/05-12/31/09. The estimation is performed without a constant, consistent with the calendar day hypothesis. The error term is modeled as $h_t^2 = \exp\left(\alpha_0 + \alpha_1 Mid + \alpha_2 Late\right) + \alpha_3 e_{t-1}^2 + \alpha_4 h_{t-1}^2$, a GARCH(1,1) process with multiplicative heteroscedasticity.

This maximum likelihood estimation allows the model to fit the early, mid, and late subsamples with different slopes for each coefficient, and it allows me to test the equality of the coefficients across time. The results of the table should be compared to Table 14. For the value-weighted index, the results of the mean equation are similar to those found in Table 14, though the coefficient on the payment delay factor for each time period is slightly smaller. For example, in the early subperiod, the coefficient on ΔF_t drops from 3.72 to 3.36. In the conditional variance equation, the constant captures the early period, and the other indicators reflect the difference in the mid and late periods. While insignificant, the mid period for VW appears to have the greatest conditional variance, followed by the late period and the early period.

Again, for the equal-weighted index, the results of the mean equation are similar to those found in Table 14. The conditional variance terms are all significant. The results imply that the middle period for EW again has the greatest conditional variance, but the late period conditional variance is close to it. The early subperiod has much lower conditional variance.

After estimating each model, I performed Wald tests for the equality of the coefficients on the payment delay factor across time. I cannot reject the null hypothesis that the coefficients are equal in any case. I find no difference between these subperiods in the payment delay using this model.

Estimation of Model C

Model C extends Model B, the three business day payment delay model, to include failed deliveries. Delivery failure is added to the estimation with the number of days in the holding period – given that the calendar day hypothesis holds for both indices over the entire sample period – and the payment delay factor – as buyers appear to compensate sellers for the delay over the settlement period (at a rate higher than the risk-free rate). I replace the constant in equation (26) with the number of days in the holding period. I estimate $R_t = b_0 * n_t + b_1 \Delta F_t + b_2 \Delta \Pr(Fail_t) + e_t$ using the subsample with available fails data from March 22, 2004 through December 31, 2009 to test whether changes in the probability that the seller will fail to deliver are reflected in equity returns. The new term can be thought of as a measure of the compensation for the risk of failed delivery. If the risk is negligible, then compensation will be zero due to the certainty of the transaction. However, when equity transactions do not clear and settle as they should, the risk of failed delivery may be priced in equity trades.

Results are shown in Table 15.[43] The first column reports Model A, which assume immediate payment and delivery under the calendar day hypothesis, over the sample period from 3/22/04 to 12/31/09. The next three columns reporting Models B and C use observable Fed funds rates to estimate the differential compensation for payment delays, as described in Table 4. The last three columns use actual rates over the settlement period, as described in Table 5, to estimate the differential compensation for payment delays. The results are similar when either actual or observed rates are used in the estimation. To observe the similarity, compare column (2) with column (5), or columns (3) and (6), or columns (4) and (7).

The null hypotheses that each coefficient is equal to zero can be rejected for nearly every coefficient. The only exception is for b_2 in columns (4) and (7), which is discussed in more detail below. When the probability of failed delivery is controlled for in the model, buyers compensate sellers at over four times the risk-free rate over the settlement period (b_1= 4.28-4.73 using the value-weighted index and b_1= 5.34-5.58 using the equal-weighted index). These estimates of b_1 are slightly higher than they are in Model B estimations.

In columns (3) and (6), I use the differential probability of failure on the day of trade. In other words, the change in probability of failure is the ratio of total failed shares to total shares traded on the trade day (T) minus the same ratio on the prior trading day (T-1). This measure serves as the trader's best estimate of the probability of failed delivery on

[43] The 15 missing fails data observations result in the sample size decreasing by 30 – due the variable being a change in probability of fails from one day to the next – as these observations are dropped from the estimation. I re-estimate Model C after setting the missing values of the change in the probability of failure equal to the change in the probability of failure on the prior settlement day. The results are essentially unchanged from Table 15.

Table 15. Estimation of Model C.

Maximum likelihood estimation of $R_t = b_0 * n_t + b_1 \Delta F_t + b_2 \Delta \Pr(Fail_t) + e_t$ where R_t is the daily return on the index for each trading day and n_t is the number of days in the holding period over the sample period from 3/22/04 to 12/31/09. When ΔF_t is based on observable (actual) rates, the Table 4 (5) method estimates the differential compensation for payment delays. The $\Delta \Pr(Fail_t)$ measures the differential compensation for the risk of failed delivery using the difference in fails either on T minus T-1 or on T+3 minus T+2. All estimations are performed without a constant. The GARCH(1,1) process models the error term as $h_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 h_{t-1}^2$. z-statistics are shown in parentheses. *, **, and *** denote significance at the 1%, 5%, and 10% level, respectively.

ΔF_t based on:		**Observable Rates**			**Actual Rates**		
$\Delta \Pr(Fail_t)$ based on:		n/a	T – (T-1)	T+3 – T+2	n/a	T – (T-1)	T+3 – T+2
Column:	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Model A n=1,457	**Model B** n=1,457	**Model C** n=1,427	**Model C** n=1,425	**Model B** n=1,457	**Model C** n=1,427	**Model C** n=1,425
VW index							
b_0	2.7×10^{-4}** (2.16)	3.9×10^{-4}* (2.88)	3.6×10^{-4}** (2.51)	4.0×10^{-4}* (2.78)	3.9×10^{-4}* (2.90)	3.6×10^{-4}** (2.53)	4.1×10^{-4}* (2.82)
b_1		4.05** (2.55)	4.28** (2.49)	4.48* (2.67)	4.11* (2.60)	4.36** (2.55)	4.73* (2.83)
b_2			0.113* (3.66)	-0.035 (-1.31)		0.113* (3.64)	-0.035 (-1.33)
α_0	1×10^{-6}** (2.10)	1×10^{-6}** (2.07)	2×10^{-6}** (2.35)	2×10^{-6}** (2.14)	1×10^{-6}** (2.07)	2×10^{-6}** (2.34)	2×10^{-6}** (2.14)
α_1	0.073* (6.44)	0.073* (6.31)	0.114* (7.97)	0.114* (7.63)	0.073* (6.32)	0.114* (7.97)	0.114* (7.62)
α_2	0.917* (77.35)	0.916* (74.97)	0.871* (62.22)	0.872* (58.19)	0.916* (75.02)	0.871* (62.23)	0.872* (58.11)
EW index							
b_0	2.7×10^{-4}** (2.27)	4.3×10^{-4}* (3.21)	3.9×10^{-4}* (2.81)	4.3×10^{-4}* (3.04)	4.3×10^{-4}* (3.23)	4.0×10^{-4}* (2.83)	4.4×10^{-4}* (3.07)
b_1		4.97* (3.44)	5.34* (3.49)	5.47* (3.63)	4.98* (3.47)	5.36* (3.52)	5.58* (3.71)
b_2			0.108* (3.80)	-0.027 (-1.13)		0.107* (3.78)	-0.027 (-1.14)
α_0	1×10^{-6}** (2.30)	1×10^{-6}** (2.27)	2×10^{-6}** (2.53)	2×10^{-6}** (2.30)	1×10^{-6}** (2.27)	2×10^{-6}** (2.53)	2×10^{-6}** (2.30)
α_1	0.083* (6.06)	0.084* (5.99)	0.128* (8.53)	0.121* (7.75)	0.084* (6.01)	0.128* (8.53)	0.121* (7.81)
α_2	0.905* (63.39)	0.903* (60.99)	0.853* (56.73)	0.861* (51.99)	0.903* (61.10)	0.853* (56.72)	0.860* (52.33)

settlement at T+3. Here, buyers appear to compensate sellers for an increase in the probability that the seller will fail to deliver, turning the trade into a forward contract. The results suggest that buyers will pay around 11% daily for a one unit increase in the change in probability of failed delivery (b_2= 0.113 for the VW index and b_2= 0.108 for the EW index). However, this means that the probability of failed delivery would have to change from zero to one (100% failed delivery) in one day, which is unrealistic. In fact, the values of the change in the probability of fail variable over the sample period are much less variable. As reported in Table A.3.3, the change in the probability of fail ranges from -0.066 to 0.065; the average is -4x10^{-5}, and the standard deviation is 0.007.

To better interpret this coefficient, consider a one percentage point increase in the change in probability of failed delivery from its mean. If the probability of failed delivery changes from zero to 0.01, then buyers compensate sellers with around 11 basis points daily for this higher probability of failed delivery. Consider a stock that costs $50 per share; this coefficient suggests a price change of four cents for a one standard deviation increase in the probability of fails ($50 x 0.00706 x 0.113 = $0.04).[44]

In columns (4) and (7), I use the differential probability of failure on the settlement day. The change in probability of failure is the ratio of total failed shares to total shares traded on the settlement day (T+3) minus the same ratio on the preceding settlement day (T+2). This measure serves as the trader's estimate of the probability of failed delivery assuming perfect foresight. Here, I fail to reject that b_2 is equal to zero at conventional levels of significance. However, the sign on the coefficient is negative (b_2= -0.035 for the VW index and b_2= -0.027 for the EW index), suggesting that buyers want compensation from sellers for an increase in the probability that the seller will fail to deliver. This could be plausible if the purchase price is determined by the buyer's BD who wants the option to lend the security and believes that a higher probability of failure means that the stock is more likely to be on special. In this case, the buyer's BD is losing out on the ability to lend a stock at a high specialness spread. The results, though insignificant, suggests that buyers require compensation of approximately three basis points per day for a one percentage point increase in the change in probability of failed delivery from its mean.

So b_2 could be less than zero if the buyer's BD loses out on the opportunity to lend a security on special and make a greater profit from a high specialness spread. The change in the proportion of the specialness spread to the risk-free rate over time could affect the magnitude of the estimated coefficient on the differential compensation for the probability of failed delivery. For most stocks, the specialness spread is zero, and the rebate rate is the Fed funds rate minus the lender's fixed commission of 10-20 basis points. For less than 10% of stocks, the specialness spread is positive, and the lender makes both a fixed commission and an extra fee for the stock over 20 basis points.

[44] The mean absolute change in the stock return is $|\Delta \mathrm{Pr}(\mathrm{Fail}_t)|$ x b_2 = 0.00403 x 0.113 = 0.00046, or approximately 5 basis points.

Evans et al. (2009) report that the average spread between the Fed funds and general collateral rate is 21 basis points for equities.

Assume lenders earn an average 25 basis point specialness spread over the approximate six-year sample period that includes the fails data. Moreover, the range of the Fed funds rate from 3/22/04-12/31/09 is 0.05% to 5.41%. When the risk-free rate is 5.41%, the estimate is around 1.05, whereas when the risk-free rate is 0.05%, the estimate is around 6. If the lending rate is less responsive than the risk-free rate and rates decline, then the result will be a much larger coefficient.

With perfect foresight, a buyer or his BD could estimate the probability of failed delivery on T+3, and an increase in the probability of fails on the settlement date, rather than on the trade date, measures the true impact on the buyer. The $\Delta\,\mathrm{Pr}(\mathrm{Fail_T})$ and $\Delta\,\mathrm{Pr}(\mathrm{Fail_{T+3}})$ variables are significantly and negatively correlated, with a correlation coefficient of -0.2, as reported in Table A.3.4. However, the probability of failure two and three business days in the future is very difficult for market participants to predict; the quality of their forecasts is poor. Thus, consideration of observable fails on the day of the trade is more reasonable.

See Appendix A.5 for robustness checks of Model C. First, I estimate the original equation (26), $R_t = b_0 + b_1\Delta F_t + b_2\Delta\,\mathrm{Pr}(Fail_t) + e_t$, with a constant rather than the number of days in the holding period, which follows the trade day hypothesis. In comparison to Table 15, the point estimates for b_1 in Table A.5.1 are much smaller. Using the value-weighted index and controlling for fails, the results of the payment delay coefficient suggest that buyers compensate sellers at nearly three times the risk-free rate over the settlement period (b_1= 2.68-2.91 compared with b_1= 4.28-4.73 under the calendar day hypothesis in Table 15). Using the equal-weighted index, the coefficient on the payment delay factor implies that buyers compensate sellers at just under four times the risk-free rate over the settlement period (b_1= 3.55-3.67 compared with b_1= 5.34-5.58 under the calendar day hypothesis in Table 15).

Second, I estimate the model, $R_t = b_0 + b_1(n_t - 1) + b_2\Delta F_t + b_3\Delta\,\mathrm{Pr}(Fail_t) + e_t$, based on actual rates over the settlement period corresponding to Table 5.[45] This model allows the return to vary by calendar day versus trade day during the holding period. Therefore, b_0 captures the average return for a trade day while b_1 signifies the average return for each non-trade day (weekend day or holiday) in the holding period. Over the sample period from March 22, 2004 to December 31, 2009, approximately 78% of all observations have a holding period of one day. About 18% of observations have a holding period of three days as a result of a normal weekend. The remaining 4% are the result of holidays, and the holding period is generally either two or four days. This is the same pattern of number of days in the holding period that is observed over the longer sample period used to estimate Model B above.

[45] Results are similar using observed rates for the payment delay factor.

Table A.5.2 shows that the constant term, b_0, is statistically insignificant for the value-weighted index, but the opposite result is found for the equal-weighted index. In other words, the null hypothesis that the constant is equal to zero cannot be rejected for every estimation using VW, but it can be rejected for every estimation using EW. The non-trade days in the holding period are slightly significant for the VW estimations (at the 9% to 12% level) but insignificant for EW. This suggests that the calendar day model in Table 15 better fits VW while the trade day model in Table A.5.1 better fits EW.

Using VW, the payment delay factor implies compensation from buyers to sellers at over five times the risk-free rate over the settlement period (b_2=5.36 or 5.44) for the estimations that include the variable relating to fails. This is somewhat larger than the results in Table 15, where the payment delay factor is about four and a half times the risk-free rate (b_1=4.36 or 4.73), and it is nearly twice the magnitude of the estimates shown in Table A.5.1 (b_1=2.85 or 2.91). Using EW, the payment delay factor implies compensation from buyers to sellers at about five times the risk-free rate over the settlement period (b_2=4.81 or 5.11) for the estimations that include the variable relating to fails. This is slightly smaller than the results in Table 15 (b_1=5.36 or 5.58), and it is 30-40% larger than the magnitude of the estimates shown in Table A.5.1 (b_1=3.67 or 3.66). The estimates of the coefficient on the differential compensation for fails variable are consistent with both Table 15 and Table A.5.1.

Next, I re-estimate $R_t = b_0 + b_1(n_t - 1) + b_2\Delta F_t + b_3\Delta\,\Pr(Fail_t) + e_t$ over the period of time when Rules 204T and 204 were effective. Temporary Rule 204T was effective from October 17, 2008 through July 31, 2009; it was extended permanently, without interruption, by Rule 204. I use actual rates to compute the differential compensation for payment delays. I use the differential compensation for probability of failure on the day of the trade. A Wald test is performed under maximum likelihood estimation by constraining all coefficients except the intercept to zero in the mean equation while allowing the equation for conditional variance to be unconstrained. The results of the Wald test show that both estimations in Table A.5.3 are not significant at ordinary levels, meaning that the null hypothesis that all coefficients except the intercept are equal to zero cannot be rejected.

For the value-weighted index, the insignificant point estimate on the payment delay factor is negative and much larger in absolute value than previously found. The insignificant point estimate on the fails variable is similar to that found in the previous estimation (in Table A.5.2 Column (2)). For the equal-weighted index, the insignificant point estimate on the payment delay factor is again negative and much larger in absolute value than previously found, but it is not as large as observed for the value-weighted index. The point estimate on the fails variable is individually significant at the 10% level and approximately twice that found in the previous estimation (Table A.5.2 Column (5)). While this might suggest that buyers are willing to pay sellers more for fails when it is harder for sellers to fail, interpretation is limited by the joint insignificance of the coefficients. Furthermore, the estimation of the equal-weighted index is unsound in that the α_0 coefficient is negative, and the α_1 and α_2 terms in the conditional variance equation sum to more than one (0.122+0.879=1.001).

In sum, results in Table 15 columns (3) and (6) suggest that the cost of payment delays is about four times the risk-free rate, and failed deliveries result in forward contracts. Buyers pay a premium for the benefit of a lengthened settlement period of around 11 basis points daily for an increase in the likelihood of failure of one percentage point.

If the processing system has become less risky, then the compensation for payment delays should not reflect a risk premium. The results of the coefficient on the payment delay variable suggest that buyers are forced to compensate sellers at rates much greater than the expected risk-free rate over the settlement period. The premium above the risk-free rate is surprising and suggests that the new system is not as safe as it was before the shorter settlement cycle and netting.

Risk in the equity market should be reduced by the current security processing system. Counterparty risk should be very small since the NSCC becomes the central counterparty, nets trades, and requires cash collateral for settlement. The shortened settlement cycle from T+3 to T+5 would have decreased settlement exposure by 40% simply because transactions settle two out of five business days faster. Collateral posted at the clearing corporation declined by that much as well due to fewer open trades for clearing firms at any point in time.

As discussed earlier, the conversation relating to shortening the settlement cycle has been revived in the past few years by the executives at DTCC and in international equity markets; the reason for this increased interest is to alleviate systemic risk. In 2000, the SIA estimated that shortening the settlement cycle for U.S. equities from T+3 to T+1 would decrease settlement exposure by 67% or $250 billion. The cost for the transition, while substantial at an estimated $8 billion, was projected to yield nearly $3 billion of savings per year. These estimates were made not long after the switch from T+5 to T+3, so they give a rough idea of the cost savings that should have resulted from the initial shortening of the settlement cycle by two business days.

But the results obtained in this study suggest that there is substantial risk in the payment delay due to settlement on a T+3 schedule. In fact, I approximate a huge implicit cost of the excess compensation buyers pay sellers using the following computation. I use the coefficient estimate obtained for the payment delay factor in the late sample on the value-weighted index of approximately four (using observed rates, b_1= 3.89 in Table 13 and b_1= 4.28 in Table 15; using actual rates, b_1= 3.95 in Table 14 and b_1= 4.36 in Table 15), and I take the difference from the expected payment delay factor of one, representing the risk-free rate of return over the settlement period. I multiply this premium of three by the average daily risk-free rate over the late sample period (8.37×10^{-5}) and by the available SEC market value of equity sales reported in

Table 3 for 2005 through 2008. The estimated dollar value of excess compensation ranges from $8 billion in 2005 to $20 billion in 2008.

Why are these results contradictory to expectations? And why do they suggest that the stability of the financial system is not as solid as it was in T+5? The answer is due to counterparty risk. Counterparty risk is minimized for trades processed by the central clearing agency, yet a small amount of risk still exists because trades are netted only once per day. Very large volatility during a trade day may introduce counterparty risk even with the existence of the NSCC. Technically, NSCC becomes the CCP at midnight between T+1 and T+2, when netting occurs. Therefore, the trade guarantee is not legally binding until over 30 hours after the trade occurs. However, I am unaware of any instance in which NSCC has reneged on its practical obligation to guarantee trades for which it has confirmed trade details through the comparison process. This is not the source of counterparty risk that is leading to my results.

A more realistic explanation is that counterparty risk exists and is significant in bilateral agreements that clear via channels outside of a clearing corporation. Unfortunately, no data are available to illuminate the size or scope of this practice in which individual BDs manage the exchange of information, payment, and securities. There is reciprocal exposure to both sides of the trade. If the seller fails to deliver, the buyer may have to replace the failed securities at a potentially higher price. If the buyer defaults, the seller may have to go back to the market to find a new buyer, and the possibility of selling at a lower price and incurring a loss exists.

The premium observed is the cost that results because not all trades are processed by the central clearing corporation. CRSP data captures trades in the entire market, not just those processed by the NSCC. Therefore, the result of three to five times the risk-free rate is a weighted average of the trades that are netted and guaranteed by the CCP and those that are not. If the payment delay factor for trades netted and guaranteed by the CCP is actually the risk-free rate of return over the settlement period, then it must be even larger than the observed point estimates for ex-clearing trades.

In conclusion, present-day security transaction processing should provide traders with more safety than past methods. NSCC guarantees settlement of all trades, assumes counterparty risk, and requires trading parties to deposit collateral for settlement. DTC has not only immobilized most stock certificates, but its existence has resulted in dematerialization of many stock certificates. The equity settlement cycle was shortened to T+3 in 1995. All of these advancements should have lessened systemic risks. However, this study finds that sellers are extracting compensation for potential settlement issues at much greater than the risk-free rate. This result is most likely due to bilateral agreements processed outside the clearing corporation.

VII. Conclusion

This study demonstrates many interesting results. First, equity returns over the sample period are best described with a GARCH(1,1) model. Second, the calendar day hypothesis holds in this sample, meaning that the return on equity indices depends on the number of days in the holding period. Third, sellers demand compensation in excess of the risk-free rate of return for the payment delay from settlement on T+3. This may reveal a premium for uncertainty about getting paid on time for transactions processed outside of the central clearing corporation. I measure the cost of payment delays to be approximately three to five times the risk-free rate, suggesting that buyers are forced to compensate sellers at rates greater than the expected risk-free rate during normal conditions. Fourth, failed deliveries result in forward contracts, so as the probability of failed delivery increases, buyers pay a premium for this benefit. I find that buyers compensate sellers over the lengthened settlement period due to failed deliveries at a rate of approximately 11 basis points daily for an increase in the likelihood of failure of one percentage point.

VIII. Future Research

Future research calls for a deeper investigation into compensation for payment delays and failed deliveries. Why are the improvements in the post-trade processing systems not translating into lower risk for sellers? Are regulations regarding fails serving their intended purpose?

To better understand failures to deliver, I would like to investigate determinants of the probability of failure to deliver particular stocks based on characteristics, such as market capitalization, institutional ownership, and market to book values, that may proxy for the specialness of a stock. I could confirm and measure the link between these traits and fails using a limited dependent variable model.

Moreover, continuing with my model, I could look at individual stock returns rather than index returns. Using a market model, I could estimate the BD's daily loss from missing out on the opportunity to lend on special. I could use characteristics such as lower institutional ownership and market capitalization and higher market-to-book ratios as proxies for stocks that are on special. I could estimate the daily benefit from an extension of the payment delay for individual securities. Using these estimates would give me an idea of the cost-benefit analysis a BD may perform when purchasing stocks.

I could test whether BDs are more influenced by a potential extension of the payment delay when a stock is easy to borrow versus whether BDs are more influenced by the lost opportunity to lend a stock on special when it is hard to borrow. In particular, I could test whether the coefficient on my change in probability of fails variable is positive when the benefit from the extension of the payment delay is more valuable and negative when the benefit from the opportunity to lend on special is more valuable. For example, I could split my sample into two groups based on whether the lost opportunity to lend dominates or the payment delay extension dominates. If the coefficient on the probability of fails had opposite signs for the two groups, then assuming the model is correct, the theoretical insight is confirmed empirically.

I could also investigate differential compensation for failures for firms that delist. When a firm delists, the fail persists. The issue generally keeps trading in the pink sheets, where delivery requirements are maintained, and NSCC's CNS system continues to process unlisted stocks. For example, General Motors (GM) dissolved on June 1, 2009. GM fails grew prior to insolvency and peaked on June 5, 2009. Fails remained high for around six more weeks. As this was prior to Rule 204T, a short seller potentially saved a significant amount by choosing to fail because he would not incur a lending fee. It may be difficult to borrow around this type of event due to lots of short selling, meaning that the stock may be expensive to borrow. But that also means that the buy side is losing out on the opportunity to lend this stock on special Therefore, I would expect to see discounts in prices attributable to the probability of failure for a sample of delisting firms as opposed to the premium I found in this study on a market sample.

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Appendix

Appendix A.1. Settlement Schedules

Approximately 20% of weeks have a business holiday.

Case A: T+3 and no holiday

# calendar days	M	Tu	W	Th	F	S	Su	M	Tu	W	Th	F
3	T	1	2	3								
3		T	1	2	3							
5			T	1	2			3				
5				T	1			2	3			
5					T			1	2	3		

Case B: T+3 and Monday holiday (MLK, Washington's Birthday, Memorial Day, Labor Day & occasionally Jan 1, Jul 4, or Dec 25)

# calendar days	M	Tu	W	Th	F	S	Su	M	Tu	W	Th	F
3		T	1	2	3							
6			T	1	2				3			
6				T	1				2	3		
6					T				1	2	3	

Case C: T+3 and Friday holiday (Good Friday & occasionally Jan 1, Jul 4, or Dec 25)

# calendar days	M	Tu	W	Th	F	S	Su	M	Tu	W	Th	F
3	T	1	2	3								
6		T	1	2				3				
6			T	1				2	3			
6				T				1	2	3		

Case D: T+3 and Thursday holiday (Thanksgiving & occasionally Jan 1, Jul 4, or Dec 25)

# calendar days	M	Tu	W	Th	F	S	Su	M	Tu	W	Th	F
4	T	1	2		3							
6		T	1		2			3				
6			T		1			2	3			
5					T			1	2	3		

Case E: T+3 and Tuesday holiday (occasionally Jan 1, Jul 4, or Dec 25)

# calendar days	M	Tu	W	Th	F	S	Su	M	Tu	W	Th	F
5			T	1	2			3				
6				T	1			2		3		
6					T			1		2	3	
4								T		1	2	3

Case F: T+3 and Wednesday holiday (occasionally Jan 1, Jul 4, or Dec 25)

# calendar days	M	Tu	W	Th	F	S	Su	M	Tu	W	Th	F	S	Su	M
5				T	1			2	3						
6					T			1	2		3				
4								T	1		2	3			
6									T		1	2			3

Appendix A.2. Differential Compensation for Payment Delays

The following table shows the abbreviations used for the days of the week and the number of calendar days, D_t, in the settlement period during weeks without holidays.

Day	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Abbreviation	M	T	W	R	F	S	Su
D_t	3	3	5	5	5	n/a	n/a

The general equation for differential compensation for payment delays on trade date t, Δc_t, is given by the following.

$$\Delta c_t = \left[\sum_{i=1}^{D_t} c_{i,t}\right] - \left[\sum_{i=1}^{D_{t-1}} c_{i,t-1}\right]$$

1. Differential compensation for payment delays on a Monday (M) trade date, Δc_M.

$$\Delta c_M = \left[\sum_{i=1}^{D_M} c_{i,M}\right] - \left[\sum_{i=1}^{D_F} c_{i,F}\right] = \left[\sum_{i=1}^{3} c_{i,M}\right] - \left[\sum_{i=1}^{5} c_{i,F}\right]$$

For a trade that occurs during a week without a holiday and on a Monday, D_t is equal to three since the trade will settle in three calendar days. For a trade that occurs during a week without a holiday and on a Friday, D_t is equal to five since the trade will settle in five calendar days (three business days plus two additional days in the intervening weekend.)

For the Monday trade, the term in the first pair of brackets is the sum of (1) the compensation on Tuesday as determined on Monday, plus (2) the compensation on Wednesday as determined on Monday, plus (3) the compensation on Thursday as determined on Monday.

For the preceding Friday trade, the term in the second pair of brackets is the sum of (1) the compensation on Saturday as determined on Friday, plus (2) the compensation on Sunday as determined on Friday, plus (3) the compensation on Monday as determined on Friday, plus (4) the compensation on Tuesday as determined on Friday, plus (5) the compensation on Wednesday as determined on Friday.

$$\Delta c_M = [c_{T,M} + c_{W,M} + c_{R,M}] - [c_{S,F} + c_{Su,F} + c_{M,F} + c_{T,F} + c_{W,F}]$$

If the agreed upon compensation for any given day in the settlement period (e.g. Tuesday) is the same – or if the difference is negligible – for trades on either Friday and

Monday, then I can simplify by dropping the trade day subscripts, M or F. However, if the compensation on Tuesday is different depending on whether the trade is on Friday or Monday, then this simplification introduces error into the model.

$$\Delta \mathrm{c_M} = [\mathrm{c_T} + \mathrm{c_W} + \mathrm{c_R}] - [\mathrm{c_S} + \mathrm{c_{Su}} + \mathrm{c_M} + \mathrm{c_T} + \mathrm{c_W}] = \mathrm{c_R} - \mathrm{c_S} - \mathrm{c_{Su}} - \mathrm{c_M}$$

This says that the differential compensation for payment delays on a Monday trade date is equal to the difference between the compensation on Thursday minus the combined compensation for Saturday, Sunday, and Monday.

2. Differential compensation for payment delays on a Tuesday (T) trade date, $\Delta \mathrm{c_T}$.

$$\Delta \mathrm{c_T} = \left[\sum_{i=1}^{D_\mathrm{T}} c_{i,\mathrm{T}}\right] - \left[\sum_{i=1}^{D_\mathrm{M}} c_{i,\mathrm{M}}\right] = \left[\sum_{i=1}^{3} c_{i,\mathrm{T}}\right] - \left[\sum_{i=1}^{3} c_{i,\mathrm{M}}\right]$$

For a trade that occurs during a week without a holiday and on a Monday or a Tuesday, $\mathrm{D_t}$ is equal to three since the trade will settle in three calendar days.

Following the method employed above:

$$\Delta \mathrm{c_T} = \left[\mathrm{c_{W,T}} + \mathrm{c_{R,T}} + \mathrm{c_{F,T}}\right] - \left[\mathrm{c_{T,M}} + \mathrm{c_{W,M}} + \mathrm{c_{R,M}}\right]$$

Again, I can simplify by dropping the trade day subscripts (second subscripts), T or M, if the agreed upon compensation for Wednesday is the same – or if the difference is negligible – for trades on either Monday or Tuesday and if the agreed upon compensation for Thursday is the same – or if the difference is negligible – for trades on either Monday or Tuesday.

$$\Delta \mathrm{c_T} = [\mathrm{c_W} + \mathrm{c_R} + \mathrm{c_F}] - [\mathrm{c_T} + \mathrm{c_W} + \mathrm{c_R}] = \mathrm{c_F} - \mathrm{c_T}$$

This says that the differential compensation for payment delays on a Tuesday trade date is equal to the difference between the compensation on Friday minus the compensation on Tuesday.

3. Differential compensation for payment delays on a Wednesday (W), $\Delta \mathrm{c_W}$.

$$\Delta \mathrm{c_W} = \left[\sum_{i=1}^{D_W} c_{i,\mathrm{W}}\right] - \left[\sum_{i=1}^{D_\mathrm{T}} c_{i,\mathrm{T}}\right] = \left[\sum_{i=1}^{5} c_{i,\mathrm{W}}\right] - \left[\sum_{i=1}^{3} c_{i,\mathrm{T}}\right]$$

$$\Delta \mathrm{c_W} = \left[\mathrm{c_{R,W}} + \mathrm{c_{F,W}} + \mathrm{c_{S,W}} + \mathrm{c_{Su,W}} + \mathrm{c_{M,W}}\right] - \left[\mathrm{c_{W,T}} + \mathrm{c_{R,T}} + \mathrm{c_{F,T}}\right]$$

Simplify by dropping the trade day subscripts (second subscripts.)

$$\Delta c_{\mathrm{W}} = [c_{\mathrm{R}} + c_{\mathrm{F}} + c_{\mathrm{S}} + c_{\mathrm{Su}} + c_{\mathrm{M}}] - [c_{\mathrm{W}} + c_{\mathrm{R}} + c_{\mathrm{F}}] = c_{\mathrm{S}} + c_{\mathrm{Su}} + c_{\mathrm{M}} - c_{\mathrm{W}}$$

This says that the differential compensation for payment delays on a Wednesday trade date is equal to the difference between the combined compensation for Saturday, Sunday, and Monday minus the compensation on Wednesday.

4. Differential compensation for payment delays on a Thursday (R) trade date, Δc_{R}.

$$\Delta c_{\mathrm{R}} = \left[\sum_{i=1}^{D_R} c_{i,\mathrm{R}}\right] - \left[\sum_{i=1}^{D_{\mathrm{W}}} c_{i,\mathrm{W}}\right] = \left[\sum_{i=1}^{5} c_{i,\mathrm{R}}\right] - \left[\sum_{i=1}^{5} c_{i,\mathrm{W}}\right]$$

$$\Delta c_{\mathrm{R}} = \left[c_{\mathrm{F,R}} + c_{\mathrm{S,R}} + c_{\mathrm{Su,R}} + c_{\mathrm{M,R}} + c_{\mathrm{T,R}}\right] - \left[c_{\mathrm{R,W}} + c_{\mathrm{F,W}} + c_{\mathrm{S,W}} + c_{\mathrm{Su,W}} + c_{\mathrm{M,W}}\right]$$

Simplify by dropping the trade day subscripts (second subscripts.)

$$\Delta c_{\mathrm{R}} = [c_{\mathrm{F}} + c_{\mathrm{S}} + c_{\mathrm{Su}} + c_{\mathrm{M}} + c_{\mathrm{T}}] - [c_{\mathrm{R}} + c_{\mathrm{F}} + c_{\mathrm{S}} + c_{\mathrm{Su}} + c_{\mathrm{M}}] = c_{\mathrm{T}} - c_{\mathrm{R}}$$

This says that the differential compensation for payment delays on a Thursday trade date is equal to the difference between the compensation on Tuesday minus the compensation on Thursday.

5. Differential compensation for payment delays on a Friday (F) trade date, Δc_{F}.

$$\Delta c_{\mathrm{F}} = \left[\sum_{i=1}^{D_F} c_{i,\mathrm{F}}\right] - \left[\sum_{i=1}^{D_R} c_{i,\mathrm{R}}\right] = \left[\sum_{i=1}^{5} c_{i,\mathrm{F}}\right] - \left[\sum_{i=1}^{5} c_{i,\mathrm{R}}\right]$$

$$\Delta c_{\mathrm{F}} = \left[c_{\mathrm{S,F}} + c_{\mathrm{Su,F}} + c_{\mathrm{M,F}} + c_{\mathrm{T,F}} + c_{\mathrm{W,F}}\right] - \left[c_{\mathrm{F,R}} + c_{\mathrm{S,R}} + c_{\mathrm{Su,R}} + c_{\mathrm{M,R}} + c_{\mathrm{T,R}}\right]$$

Simplify by dropping the trade day subscripts (second subscripts.)

$$\Delta c_{\mathrm{F}} = [c_{\mathrm{S}} + c_{\mathrm{Su}} + c_{\mathrm{M}} + c_{\mathrm{T}} + c_{\mathrm{W}}] - [c_{\mathrm{F}} + c_{\mathrm{S}} + c_{\mathrm{Su}} + c_{\mathrm{M}} + c_{\mathrm{T}}] = c_{\mathrm{W}} - c_{\mathrm{F}}$$

This says that the differential compensation for payment delays on a Friday trade date is equal to the difference between the compensation on Wednesday minus the compensation on Friday.

Differential compensation for payment delays for each trade day of the week during weeks without holidays are summarized in Table 5.

Appendix A.3. Additional Summary Statistics

Table A.3.1. Daily return of CRSP market portfolio indices over the full sample period.

The Standard and Poor's (S&P) 500 Composite Index does not include dividends and is weighted by the market value of its components; therefore, it is most comparable to the value-weighted index without dividends.

	Value-Weighted		Equal-Weighted		S&P 500
	with dividends	without dividends	with dividends	without dividends	without dividends
average	0.000373	0.000302	0.000845	0.000776	0.000284
median	0.000886	0.000814	0.001697	0.001628	0.000649
maximum	0.115182	0.115118	0.107385	0.107294	0.115800
minimum	-0.089931	-0.090012	-0.080311	-0.080389	-0.090350
variance	0.000165	0.000165	0.000117	0.000117	0.000168
standard deviation	0.012829	0.012829	0.010811	0.010813	0.012975

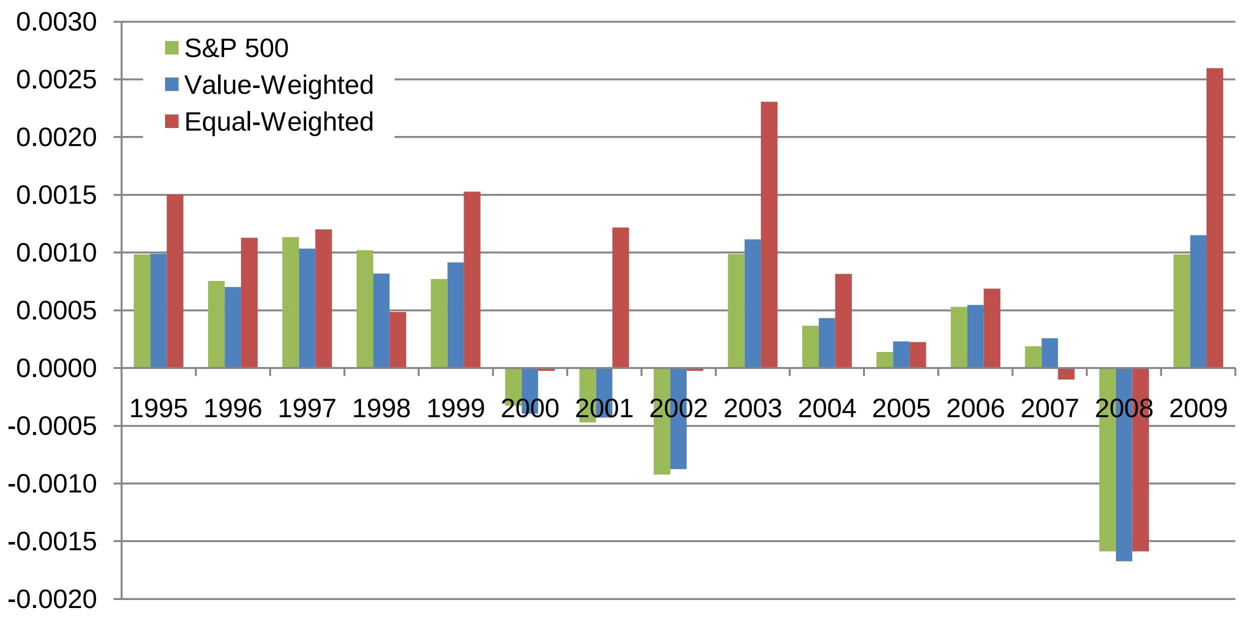

Figure A.3.1. Average daily returns by year and index (without dividends).

Table A.3.2. Arithmetic and geometric average daily return (%) by index.

	Value-Weighted Index with Dividends	Equal-Weighted Index with Dividends
Payment Delay Full Sample (6/7/95 to 12/31/09) n = 3,670		
arithmetic	0.0373	0.0845
geometric	0.0294	0.0786
Early Subperiod (6/7/95 – 12/31/99) n = 1,155		
arithmetic	0.0949	0.1195
geometric	0.0903	0.1171
Middle Subperiod (1/3/00 – 12/31/04) n = 1,256		
arithmetic	0.0033	0.0922
geometric	-0.0049	0.0873
Late Subperiod (1/3/05 – 12/31/09) n = 1,259		
arithmetic	0.0183	0.0446
geometric	0.0068	0.0347

Table A.3.3. Sample statistics for differential compensation measures.

The ΔF_t variable estimates the differential compensation for payment delays and is based on observable or actual rates, based on the Table 4 or Table 5 method, respectively. The $\Delta \Pr(\mathrm{Fail_t})$ variable measures the differential compensation for the probability of failed delivery. The $|\Delta \Pr(\mathrm{Fail_t})|$ variable measures the absolute differential compensation for the probability of failed delivery. The fails statistics are unaffected by the use of the difference in fails either on T minus T-1 or on T+3 minus T+2; those computed at T minus T-1 are reported here.

	observations	**mean**	**standard deviation**	**minimum**	**minimum**
Payment Delay Full Sample (6/7/95 to 12/31/09)					
ΔF_t (observed rates)	3,669	-2.3×10^{-7}	0.00016	-0.00053	0.00069
ΔF_t (actual rates)	3,669	-2.2×10^{-7}	0.00016	-0.00056	0.00054
Failed Delivery Sample (3/22/04 to 12/31/09)					
ΔF_t (observed rates)	1,457	-8.8×10^{-8}	0.00013	-0.00044	0.00044
ΔF_t (actual rates)	1,457	-8.4×10^{-8}	0.00013	-0.00044	0.00044
$\Delta \Pr(\mathrm{Fail_t})$ (excluding ADRs)	1,427	-0.00004	0.00706	-0.06554	0.06472
$\lvert\Delta \Pr(\mathrm{Fail_t})\rvert$ (excluding ADRs)	1,427	0.00403	0.00579	6×10^{-6}	0.06554
$\Delta \Pr(\mathrm{Fail_T})$ (including ADRs)	1,427	-0.00004	0.00708	-0.06551	0.06567
$\lvert\Delta \Pr(\mathrm{Fail_T})\rvert$ (including ADRs)	1,427	0.00409	0.00577	5×10^{-7}	0.06567

Table A.3.4. Pair wise correlation coefficients.

Correlations between the dependent and independent variables for pair wise combinations over the fails sample from 3/22/04-12/31/09 are shown. R_t is the VW or EW index return, n_t is the number of days in the holding period, ΔF_t is the differential compensation for payment delay based on actual rates, $\Delta \Pr(\mathrm{Fail_T})$ is the differential compensation for probability of fail on the trade day (T), and $\Delta \Pr(\mathrm{Fail_{T+3}})$ is the differential compensation for probability of fail on the settlement day (T+3). For the VW (EW) index, fails of ADRs are excluded (included). The significance level of the correlation coefficient is reported on the second line.

	R_t	n_t	ΔF_t	$\Delta \Pr(\mathrm{Fail_T})$	$\Delta \Pr(\mathrm{Fail_{T+3}})$
Value-Weighted Index					
R_t	1.000				
n_t	-0.032 (0.23)	1.000			
ΔF_t	0.035 (0.18)	-0.648 (0.00)	1.000		
$\Delta \Pr(\mathrm{Fail_T})$	0.061 (0.02)	0.049 (0.06)	-0.087 (0.00)	1.000	
$\Delta \Pr(\mathrm{Fail_{T+3}})$	-0.003 (0.91)	-0.004 (0.89)	0.042 (0.12)	-0.173 (0.00)	1.000
Equal-Weighted Index					
R_t	1.000				
n_t	-0.050 (0.06)	1.000			
ΔF_t	0.040 (0.12)	-0.648 (0.00)	1.000		
$\Delta \Pr(\mathrm{Fail_T})$	0.069 (0.01)	0.059 (0.03)	-0.095 (0.00)	1.000	
$\Delta \Pr(\mathrm{Fail_{T+3}})$	-0.002 (0.93)	-0.006 (0.82)	0.052 (0.05)	-0.180 (0.00)	1.000

Appendix A.4. Robustness Checks for Model B

Table A.4.1. Model B estimation using observable rates and trade day hypothesis.

Maximum likelihood estimation of $R_t = b_0 + b_1 \Delta F_t + e_t$ where R_t is the daily return on the index for each trading day. ΔF_t is the differential compensation for payment delays from Table 4, using rates observable to the investor on the day of the trade. The estimation is performed with a constant, consistent with the trade day hypothesis. The error term is modeled as a GARCH(1,1) process. Estimates of b_0, b_1, α_0, α_1, and α_2 are reported. z-statistics are shown in parentheses.

	Full Sample 6/7/95-12/31/09 n=3,669	**Early Sample** 6/7/95-12/31/99 n=1,154	**Middle Sample** 1/3/00-12/31/04 n=1,256	**Late Sample** 1/3/05-12/31/09 n=1,259
VW index				
b_0	7.2×10^{-4}* (4.94)	11.7×10^{-4}* (4.91)	5.4×10^{-4}*** (1.89)	5.3×10^{-4}** (2.23)
b_1	1.20 (1.34)	1.16 (1.02)	-0.29 (-0.10)	2.21 (1.48)
α_0	1×10^{-6}* (2.85)	2×10^{-6}*** (1.67)	1×10^{-6}*** (1.65)	1×10^{-6}** (2.03)
α_1	0.088* (6.87)	0.113* (2.63)	0.086* (4.40)	0.085* (6.65)
α_2	0.904* (70.98)	0.874* (20.27)	0.907* (45.15)	0.905* (69.97)
EW index				
b_0	13.3×10^{-4}* (10.23)	18.9×10^{-4}* (9.99)	15.1×10^{-4}* (5.95)	6.1×10^{-4}* (2.58)
b_1	2.14* (3.42)	2.10* (2.87)	1.12 (0.59)	2.96** (2.19)
α_0	2×10^{-6}* (3.85)	4×10^{-6}* (3.07)	4×10^{-6}* (3.23)	1×10^{-6}** (2.31)
α_1	0.143* (7.27)	0.306* (3.97)	0.147* (5.74)	0.094* (6.79)
α_2	0.837* (44.58)	0.626* (9.54)	0.811* (26.90)	0.892* (64.27)

* significant at the 1% level
** significant at the 5% level
*** significant at the 10% level

Table A.4.2. Model B estimation using actual rates and trade day hypothesis.

Maximum likelihood estimation of $R_t = b_0 + b_1 \Delta F_t + e_t$ where R_t is the daily return on the index for each trading day. ΔF_t is the differential compensation for payment delays from Table 5, using rates over the actual settlement period. The estimation is performed with a constant, consistent with the trade day hypothesis. The error term is modeled as a GARCH(1,1) process. Estimates of b_0, b_1, α_0, α_1, and α_2 are reported. z-statistics are shown in parentheses.

	Full Sample 6/7/95-12/31/09 n=3,669	**Early Sample** 6/7/95-12/31/99 n=1,154	**Middle Sample** 1/3/00-12/31/04 n=1,256	**Late Sample** 1/3/05-12/31/09 n=1,259
VW index				
$\boldsymbol{b_0}$	7.2×10^{-4}* (4.94)	11.7×10^{-4}* (4.91)	5.4×10^{-4}*** (1.89)	5.3×10^{-4}** (2.23)
$\boldsymbol{b_1}$	1.32 (1.43)	1.40 (1.18)	-0.46 (-0.16)	2.27 (1.53)
$\boldsymbol{\alpha_0}$	1×10^{-6}* (2.84)	2×10^{-6}*** (1.68)	1×10^{-6}*** (1.65)	1×10^{-6}** (2.03)
$\boldsymbol{\alpha_1}$	0.088* (6.88)	0.113* (2.64)	0.086* (4.40)	0.085* (6.65)
$\boldsymbol{\alpha_2}$	0.904* (71.20)	0.875* (20.42)	0.907* (45.11)	0.905* (70.01)
EW index				
$\boldsymbol{b_0}$	13.3×10^{-4}* (10.22)	18.9×10^{-4}* (9.95)	15.1×10^{-4}* (5.96)	6.1×10^{-4}* (2.58)
$\boldsymbol{b_1}$	2.18* (3.48)	2.11* (2.89)	1.06 (0.56)	2.99** (2.22)
$\boldsymbol{\alpha_0}$	2×10^{-6}* (3.85)	4×10^{-6}* (3.06)	4×10^{-6}* (3.23)	1×10^{-6}** (2.31)
$\boldsymbol{\alpha_1}$	0.142* (7.29)	0.303* (3.95)	0.147* (5.74)	0.094* (6.80)
$\boldsymbol{\alpha_2}$	0.837* (44.75)	0.628* (9.46)	0.811* (26.93)	0.892* (64.30)

* significant at the 1% level
** significant at the 5% level
*** significant at the 10% level

Table A.4.3. Model B estimation using actual rates and a hybrid calendar-trade day hypothesis.

Maximum likelihood estimation of $R_t = b_0 + b_1(n_t - 1) + b_2\Delta F_t + e_t$ where R_t is the daily return on the index for each trading day and n_t is the number of days in the holding period. ΔF_t is the differential compensation for payment delays from Table 5, using rates over the actual settlement period. The estimation is performed with a constant, allowing trade days and non-trade days in the holding period to have different returns. The error term is modeled as a GARCH(1,1) process. Estimates of b_0, b_1, b_2, α_0, α_1, and α_2 are reported. z-statistics are shown in parentheses.

	Full Sample 6/7/95-12/31/09 n=3,669	**Early Sample** 6/7/95-12/31/99 n=1,154	**Middle Sample** 1/3/00-12/31/04 n=1,256	**Late Sample** 1/3/05-12/31/09 n=1,259
VW index				
b_0	6.3x10^{-4}* (3.39)	12.3x10^{-4}* (3.89)	6.3x10^{-4}*** (1.78)	1.8x10^{-4} (0.62)
b_1	1.9x10^{-4} (0.72)	-1.3x10^{-4} (-0.30)	-2.1x10^{-4} (-0.42)	7.7x10^{-4}** (2.00)
b_2	2.02 (1.61)	0.96 (0.55)	-1.56 (-0.43)	5.31** (2.55)
α_0	1x10^{-6}* (2.83)	2x10^{-6}*** (1.69)	1x10^{-6}*** (1.65)	1x10^{-6}** (2.00)
α_1	0.088* (6.87)	0.112* (2.67)	0.086* (4.45)	0.083* (6.56)
α_2	0.904* (71.12)	0.875* (20.69)	0.907* (45.51)	0.906* (70.27)
EW index				
b_0	15.2x10^{-4}* (9.50)	22.4x10^{-4}* (10.27)	17.3x10^{-4}* (5.88)	3.9x10^{-4} (1.39)
b_1	-4.2x10^{-4}** (-2.05)	-8.2x10^{-4}* (-3.01)	-5.2x10^{-4} (-1.31)	4.6x10^{-4} (1.33)
b_2	0.65 (0.70)	-0.72 (-0.63)	-1.29 (-0.53)	4.86** (2.49)
α_0	2x10^{-6}* (3.86)	4x10^{-6}* (3.04)	4x10^{-6}* (3.21)	1x10^{-6}** (2.29)
α_1	0.142* (7.39)	0.290* (4.12)	0.146* (5.88)	0.093* (6.76)
α_2	0.838* (45.54)	0.642* (10.21)	0.812* (27.25)	0.893* (64.22)

* significant at the 1% level
** significant at the 5% level
*** significant at the 10% level

Table A.4.4. GARCH-in-mean estimation of Model B based on actual rates and calendar day hypothesis.

Maximum likelihood estimation of $R_t = b_0 n_t + b_1 \Delta F_t + b_2 h_t^2 + e_t$, a GARCH-in-mean model, where R_t is the daily return on the index for each trading day and n_t is the number of days in the holding period. ΔF_t is the differential compensation for payment delays from Table 5, using rates over the actual settlement period. The estimation is performed without a constant, consistent with the calendar day hypothesis. The error term is modeled as a GARCH(1,1) process such that $h_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 h_{t-1}^2$. Estimates of b_0, b_1, b_2, α_0, α_1, and α_2 are reported. z-statistics are shown in parentheses.

	Full Sample 6/7/95-12/31/09 n=3,669	**Early Sample** 6/7/95-12/31/99 n=1,154	**Middle Sample** 1/3/00-12/31/04 n=1,256	**Late Sample** 1/3/05-12/31/09 n=1,259
VW index				
b_0	$2.9\text{x}10^{-4}$**	$2.5\text{x}10^{-4}$	$-0.5\text{x}10^{-4}$	$4.0\text{x}10^{-4}$**
	(2.41)	(1.13)	(-0.18)	(2.18)
b_1	2.43**	2.17	-0.76	3.83**
	(2.40)	(1.62)	(-0.24)	(2.33)
b_2	3.27**	11.4*	5.11	0.69
	(2.02)	(3.09)	(1.62)	(0.28)
α_0	$1\text{x}10^{-6}$*	$2\text{x}10^{-6}$***	$1\text{x}10^{-6}$***	$1\text{x}10^{-6}$**
	(2.85)	(1.76)	(1.70)	(2.00)
α_1	0.089*	0.115*	0.088*	0.084*
	(6.90)	(2.63)	(4.48)	(6.60)
α_2	0.903*	0.871*	0.904*	0.905*
	(70.43)	(19.97)	(43.66)	(69.46)
EW index				
b_0	$4.7\text{x}10^{-4}$*	$6.6\text{x}10^{-4}$*	$0.4\text{x}10^{-4}$	$3.1\text{x}10^{-4}$***
	(4.31)	(3.50)	(0.13)	(1.74)
b_1	3.98*	4.41*	1.27	4.24*
	(5.46)	(4.57)	(0.58)	(2.81)
b_2	6.60*	14.6*	14.9*	2.91
	(3.85)	(3.26)	(3.52)	(1.15)
α_0	$2\text{x}10^{-6}$*	$5\text{x}10^{-6}$*	$4\text{x}10^{-6}$*	$1\text{x}10^{-6}$**
	(3.91)	(3.13)	(3.24)	(2.28)
α_1	0.137*	0.271*	0.138*	0.094*
	(7.22)	(3.50)	(5.42)	(6.79)
α_2	0.842*	0.641*	0.815*	0.893*
	(45.39)	(8.92)	(26.18)	(64.08)

* significant at the 1% level
** significant at the 5% level
*** significant at the 10% level

Table A.4.5. Model B estimation to test equality of coefficients.

Estimation of $R_t = b_0 n_t Early + b_1 n_t Mid + b_2 n_t Late + b_3 \Delta F_t Early + b_4 \Delta F_t Mid + b_5 \Delta F_t Late + e_t$ where R_t is the daily return on the index for each trading day, and n_t is the number of days in the holding period. Early is an indicator variable equal to one if the date is from 6/7/95 to 12/31/99. Mid is an indicator variable equal to one if the date is from 1/3/00 to 12/31/04. Late is an indicator variable equal to one if the date is from 1/3/05-12/31/09. ΔF_t is the differential compensation for payment delays from Table 5, using actual rates over the settlement period. The estimation is performed without a constant, consistent with the calendar day hypothesis. The error term is modeled as a GARCH(1,1) process with multiplicative heteroscedasticity such that $h_t^2 = \exp(\alpha_0 + \alpha_1 Mid + \alpha_2 Late) + \alpha_3 e_{t-1}^2 + \alpha_4 h_{t-1}^2$. z-statistics are shown in parentheses. *, **, and *** denote significance at the 1%, 5%, and 10% level, respectively.

	Value-Weighted Index	Equal-Weighted Index
b_0	6.4×10^{-4}* (4.25)	8.9×10^{-4}* (7.71)
b_1	2.5×10^{-4} (1.32)	7.0×10^{-4}* (4.22)
b_2	4.1×10^{-4}* (2.72)	4.3×10^{-4}* (2.96)
b_3	3.36* (2.59)	5.15* (5.87)
b_4	0.41 (0.14)	4.23** (2.10)
b_5	3.85** (2.41)	4.78* (3.40)
α_0	-13.55* (-39.13)	-13.28* (-54.11)
α_1	0.22 (0.65)	0.67* (2.95)
α_2	0.08 (0.19)	0.59** (2.00)
α_3	0.088* (6.81)	0.144* (7.00)
α_4	0.903* (68.85)	0.826* (38.94)

Appendix A.5. Robustness Checks for Model C

Table A.5.1. Model C estimation using the trade day hypothesis,

Maximum likelihood estimation of $R_t = b_0 + b_1\Delta F_t + b_2\Delta\,\mathrm{Pr}(Fail_t) + e_t$ where R_t is the daily return on the index for each trading day over the sample period from 3/22/04 to 12/31/09. When ΔF_t is based on observable (actual) rates, the Table 4 (5) method estimates the differential compensation for payment delays. The $\Delta\,\mathrm{Pr}(\mathrm{Fail_T})$ is the differential compensation for probability of fail on the trade day (change in T minus T-1), while $\Delta\,\mathrm{Pr}(\mathrm{Fail_{T+3}})$ is on the settlement day (change in T+3 minus T+2). The GARCH(1,1) process models the error term as $h_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 h_{t-1}^2$. z-statistics are shown in parentheses. *, **, and *** denote significance at the 1%, 5%, and 10% level, respectively.

ΔF_t based on:		**Observable Rates**			**Actual Rates**		
$\Delta\,\mathbf{Pr}(\mathbf{Fail_t})$ based on:		n/a	$\Delta\,\mathrm{Pr}(\mathrm{Fail_T})$	$\Delta\,\mathrm{Pr}(\mathrm{Fail_{T+3}})$	n/a	$\Delta\,\mathrm{Pr}(\mathrm{Fail_T})$	$\Delta\,\mathrm{Pr}(\mathrm{Fail_{T+3}})$
Column:	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Model A n=1,457	**Model B** n=1,457	**Model C** n=1,427	**Model C** n=1,425	**Model B** n=1,457	**Model C** n=1,427	**Model C** n=1,425
VW index							
b_0	$5.2\text{x}10^{-4}$** (2.45)	$5.2\text{x}10^{-4}$** (2.43)	$4.6\text{x}10^{-4}$** (2.06)	$5.5\text{x}10^{-4}$** (2.45)	$5.2\text{x}10^{-4}$** (2.43)	$4.6\text{x}10^{-4}$** (2.06)	$5.5\text{x}10^{-4}$** (2.45)
b_1		2.42 (1.63)	2.77*** (1.67)	2.68*** (1.65)	2.48*** (1.67)	2.85*** (1.73)	2.91*** (1.81)
b_2			0.111* (3.57)	-0.032 (-1.21)		0.111* (3.57)	-0.033 (-1.23)
α_0	$1\text{x}10^{-6}$** (2.11)	$1\text{x}10^{-6}$** (2.09)	$2\text{x}10^{-6}$** (2.38)	$2\text{x}10^{-6}$** (2.16)	$1\text{x}10^{-6}$** (2.09)	$2\text{x}10^{-6}$** (2.38)	$2\text{x}10^{-6}$** (2.16)
α_1	0.074* (6.38)	0.074* (6.31)	0.114* (7.97)	0.114* (7.60)	0.074* (6.31)	0.114* (7.97)	0.114* (7.60)
α_2	0.916* (75.66)	0.916* (74.32)	0.871* (62.23)	0.872* (58.34)	0.916* (74.35)	0.871* (62.22)	0.872* (58.27)
EW index							
b_0	$6.7\text{x}10^{-4}$* (3.17)	$6.7\text{x}10^{-4}$* (3.14)	$6.1\text{x}10^{-4}$* (2.77)	$6.6\text{x}10^{-4}$* (2.99)	$6.7\text{x}10^{-4}$* (3.14)	$6.1\text{x}10^{-4}$* (2.77)	$6.6\text{x}10^{-4}$* (3.00)
b_1		3.16** (2.35)	3.65** (2.45)	3.55** (2.44)	3.17** (2.37)	3.67** (2.47)	3.66** (2.52)
b_2			0.107* (3.73)	-0.024 (-1.00)		0.106* (3.71)	-0.025 (-1.01)
α_0	$1\text{x}10^{-6}$** (2.34)	$1\text{x}10^{-6}$** (2.31)	$2\text{x}10^{-6}$* (2.59)	$2\text{x}10^{-6}$** (2.35)	$1\text{x}10^{-6}$** (2.31)	$2\text{x}10^{-6}$* (2.58)	$2\text{x}10^{-6}$** (2.35)
α_1	0.083* (6.00)	0.084* (6.00)	0.128* (8.51)	0.122* (7.76)	0.084* (6.01)	0.128* (8.51)	0.122* (7.79)
α_2	0.903* (61.53)	0.902* (60.51)	0.852* (56.55)	0.860* (52.14)	0.902* (60.58)	0.852* (56.54)	0.860* (52.37)

Table A.5.2. Model C estimation using actual rates and a hybrid calendar-trade day hypothesis.

Maximum likelihood estimation of $R_t = b_0 + b_1(n_t - 1) + b_2\Delta F_t + b_3\Delta\Pr(Fail_t) + e_t$ where R_t is the daily return on the index for each trading day over the sample period from 3/22/04 to 12/31/09. ΔF_t is based on actual rates using the Table 5 method to estimate the differential compensation for payment delays. The $\Delta\Pr(\mathrm{Fail_T})$ is the differential compensation for probability of fail on the trade day (change in T minus T-1), and $\Delta\Pr(\mathrm{Fail_{T+3}})$ is the differential compensation for probability of fail on the settlement day (change in T+3 minus T+2). The GARCH(1,1) process models the error term as $h_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 h_{t-1}^2$. z-statistics are shown in parentheses.

	Value-Weighted Index			**Equal-Weighted Index**		
		$\Delta\Pr(\mathrm{Fail_T})$	$\Delta\Pr(\mathrm{Fail_{T+3}})$		$\Delta\Pr(\mathrm{Fail_T})$	$\Delta\Pr(\mathrm{Fail_{T+3}})$
Column:	(1)	(2)	(3)	(4)	(5)	(6)
	Model B n=1,457	**Model C** n=1,427	**Model C** n=1,425	**Model B** n=1,457	**Model C** n=1,427	**Model C** n=1,425
b_0	$2.7\text{x}10^{-4}$ (1.02)	$1.9\text{x}10^{-4}$ (0.71)	$3.0\text{x}10^{-4}$ (1.10)	$5.6\text{x}10^{-4}$** (2.18)	$4.9\text{x}10^{-4}$*** (1.87)	$5.1\text{x}10^{-4}$*** (1.94)
b_1	$5.6\text{x}10^{-4}$*** (1.68)	$5.9\text{x}10^{-4}$*** (1.65)	$5.7\text{x}10^{-4}$ (1.56)	$2.5\text{x}10^{-4}$ (0.80)	$2.7\text{x}10^{-4}$ (0.80)	$3.3\text{x}10^{-4}$ (0.94)
b_2	4.82** (2.41)	5.36** (2.45)	5.44** (2.52)	4.23** (2.24)	4.81** (2.39)	5.11** (2.49)
b_3		0.113* (3.66)	-0.036 (-1.35)		0.107* (3.76)	-0.027 (-1.10)
α_0	$1\text{x}10^{-6}$** (2.07)	$2\text{x}10^{-6}$** (2.33)	$2\text{x}10^{-6}$** (2.14)	$1\text{x}10^{-6}$** (2.30)	$2\text{x}10^{-6}$* (2.56)	$2\text{x}10^{-6}$** (2.33)
α_1	0.073* (6.29)	0.113* (7.90)	0.114* (7.57)	0.084* (5.99)	0.128* (8.51)	0.122* (7.78)
α_2	0.917* (75.19)	0.872* (61.99)	0.872* (57.94)	0.902* (60.67)	0.853* (56.58)	0.860* (52.12)

* significant at the 1% level
** significant at the 5% level
*** significant at the 10% level

Table A.5.3. Model C estimation over the Rule 204T/204 effective sample period.

Maximum likelihood estimation of $R_t = b_0 + b_1(n_t - 1) + b_2\Delta F_t + b_3\Delta\,\mathrm{Pr}(Fail_t) + e_t$ where R_t is the daily return on the index for each trading day over the sample period from 10/17/08 to 12/31/09. ΔF_t is based on actual rates using the Table 5 method to estimate the differential compensation for payment delays. The $\Delta\,\mathrm{Pr}(\mathrm{Fail_T})$ is the differential compensation for probability of fail on the trade day (change in T minus T-1). The GARCH(1,1) process models the error term as $h_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 h_{t-1}^2$. z-statistics are shown in parentheses. The significance level, Prob > chi2, of a Wald test is reported under the number of observations, n. *, **, and *** denote significance at the 1%, 5%, and 10% level, respectively.

	Value-Weighted Index n = 298 Prob > chi2 = 0.78	**Equal-Weighted Index** n = 298 Prob > chi2 = 0.21
$\boldsymbol{b_0}$	$15.8\text{x}10^{-4}$ (1.43)	$25.2\text{x}10^{-4}$** (2.34)
$\boldsymbol{b_1}$	$-3.8\text{x}10^{-4}$ (-0.22)	$-2.9\text{x}10^{-4}$ (-0.17)
$\boldsymbol{b_2}$	-97.77 (-0.36)	-29.89 (-0.13)
$\boldsymbol{b_3}$	0.127 (0.84)	0.227*** (1.88)
$\boldsymbol{\alpha_0}$	$1\text{x}10^{-6}$ (0.41)	$-2\text{x}10^{-7}$ (-0.05)
$\boldsymbol{\alpha_1}$	0.120* (4.14)	0.122* (4.29)
$\boldsymbol{\alpha_2}$	0.877* (34.76)	0.879* (40.37)

Vita

Victoria Lynn Messman was raised in the Midwest and the South. After graduating from high school in Hattiesburg, Mississippi, she enrolled at the University of Southern Mississippi to study chemistry and math, though her interests extended to music and Spanish as well. At Southern Miss, she earned a bachelor of science degree in polymer science and a Master of Business Administration degree with an emphasis in finance. During her undergraduate years, she travelled to New York, California, Florida, and Strasbourg, France to work. As a master's student, she performed research relating to health economics on various Environmental Protection Agency (EPA) grants. After graduation, she worked in the area of training and development on a Department of Labor (DOL) grant; she also got her first taste of teaching in both economics and finance and found her calling as an educator. A few years later, she returned to school to pursue a doctorate in business administration with a concentration in finance at the University of Tennessee. During her doctoral work, she served as a research and teaching assistant, where she taught hundreds of students in Principles of Finance, Investments, and Strategic Management courses. Victoria joined Maryville College in Maryville, Tennessee as an assistant professor in the fall of 2010.